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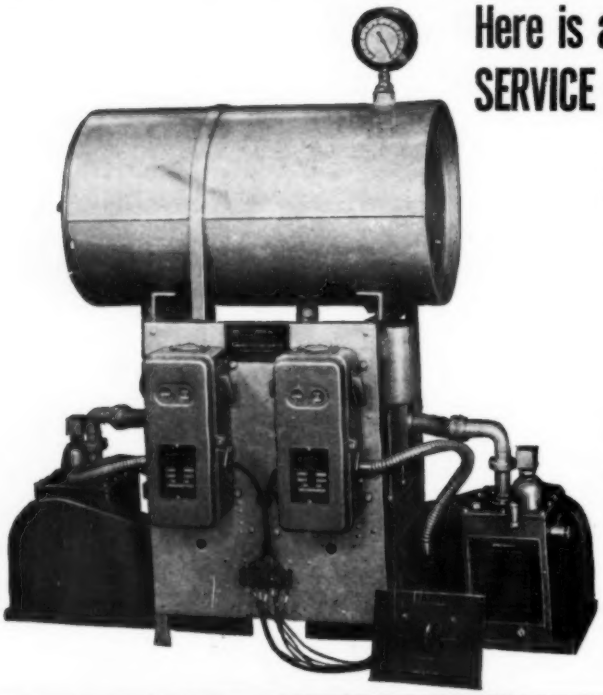

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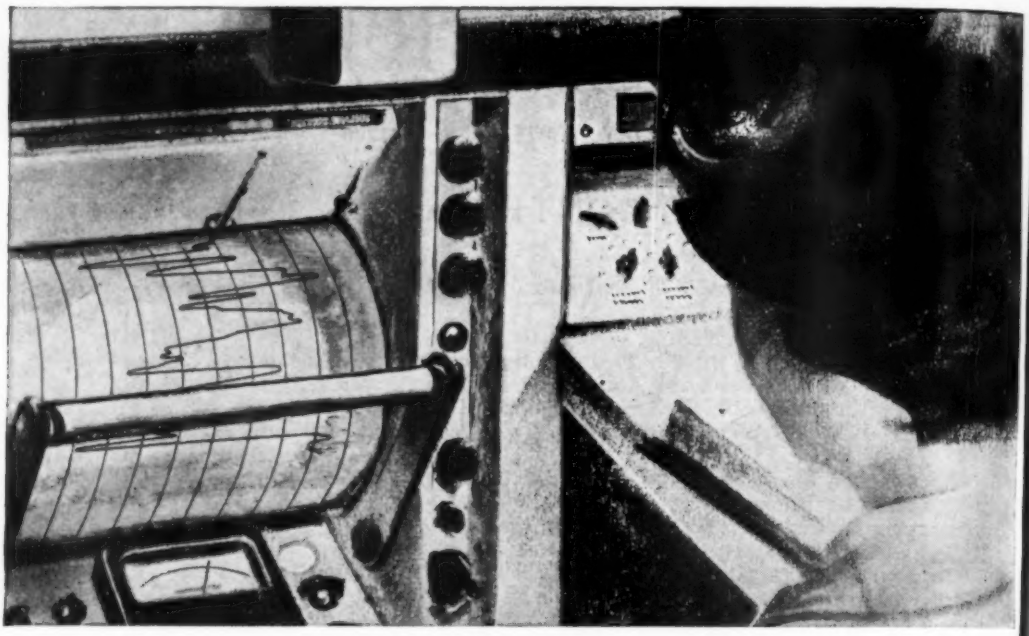

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# UNDERSTANDING AND POWER

THE two aspects of science which Sir George Thomson discusses in his presidential address to the British Association for the Advancement of Science (see p. 837 of this issue) are its contribution to man's control over Nature and its contribution to our understanding of the nature of things. At the outset, Sir George firmly repudiates the idea that the contribution which science makes to our mastery of the world in which we live is the sole or even a sufficient justification for science. Without, however, examining science as one of the great human values, along with art and religion and philosophy, he defends so firmly and lucidly the value of science as a means of understanding the world in which we live that his address naturally recalls Sir Edward Appleton's address to the Association at Liverpool in 1953 on science for its own sake. Whereas, however, Sir Edward emphasized the intrinsic value of science, it is rather with the interrelations of science and technology that Sir George Thomson is concerned, and the way in which technological advance arises out of the contribution to our understanding of the physical world that science makes possible.

Science, Sir George points out, makes an approach to understanding which is the very opposite of that of religion and philosophy. It begins by studying details, often apparently trivial details, and from this study of details come concepts. Many of these do not survive, but the successful concepts, or the best of them, are no longer concerned with details. They penetrate deep in the heart of things and unify our thoughts over a vast area of facts, enabling men's minds to grasp certain aspects of the enormous complexity of the world. They represent an extension of the human intelligence, and often are not easy to comprehend, so that their subtleties oblige the popularizer to take care lest in simplifying he makes statements which are simply untrue.

Furthermore, Sir George maintains that concepts are discoveries as well as—indeed, more than—inventions, that they are more than an exercise or product of the human mind and represent reality. Here, where he points out that, as an exercise of the human mind, they equal the brilliance of any system of thought, philosophical or even mathematical, and when he sets science in its function of enlarging the bounds of human knowledge alongside the expression of human greatness in art and morals, he seems to come close to the line of Sir Edward Appleton's thought. It is the chance of understanding things of fundamental and permanent importance that makes the pursuit of science fascinating and worth while. This and, it might be added, the intellectual and moral discipline which it imposes on those who follow it, give science its place as one of the great human values.

Sir George Thomson, however, is more concerned in this address with the interactions of this aspect of science, as a way of finding out and understanding the world in which we live, on other aspects of life than with its value to the individual as an intellectual discipline or pursuit. In our times, technological advance, in the medical as well as in the engineering field, largely and even mainly arises out of clear understanding of the principles involved; though he reminds us that this has not always been true and that in earlier centuries advances in technology were largely empirical. To-day, discoveries are increasingly made in research laboratories and fewer by workmen on the bench, and industry in general recognizes this dependence of technology on pure science. Apart from a few industries where too little is spent on research or research is badly organized, Sir George believes the need is realized and reasonably well met.

Science itself, however, receives a great return for what it contributes to technology, and this in two ways, materially and in the realm of ideas. Indeed, though Sir George did not specifically say so, some science arises out of technology. Nevertheless, he pointed out that a modern physics laboratory could not work without instruments developed for technology and obtainable chiefly because industry needs them in large numbers, and he doubted whether academic scientists are sufficiently grateful for this return by industry. Without the resources which technology and industry have placed at his disposal, the power of the scientist to enlarge the boundaries of knowledge would be very considerably restricted, and this factor alone does not make it too easy to decide on the allocation of limited resources or whether to enter on some entirely new field.

Quite as important, however, is the influence of technology in keeping science in touch with reality. As science advances, concepts tend to become more and more abstract, and further removed from anything that can literally be touched or handled; and Sir George suggests that there is a danger that we may come to suppose that some elaborate piece of mathematics represents reality when it is only a creation of the mind, inspired indeed by physical reality, but no more like it than is a modern picture. So long as those who formulate these theories are reasonably close to those who use them, not merely in laboratories but also in industry, Sir George thinks that we are safe, and to him the most amazing thing about science and the most surprising and exciting thing about our world is the astonishing connexion between highly abstruse theoretical ideas and the matter of fact. Sir George illustrates his point by referring to a household kettle heated by electricity supplied by nuclear power; the argument for some effort in space research on the grounds of the probable benefit to telephonic communications is no more unrealistic than proposals for nuclear power would have seemed less than a generation ago.

In referring to these interactions of science and technology, Sir George joins issue with those who regard technology as intellectually a poor relation of science. To him, science without technology is incomplete and inconclusive. Systems of philosophy come and go, and it is hard to suggest criteria for their truth. When, however, conclusions deduced from precise experiments by mathematical theory lead to detailed predictions from which working machines can be designed, machines which without the theory no one would have thought of in a million years, then indeed one knows that one lives in a universe which is rational and that one has found the key to one of its rooms.

From this Sir George goes on to refer to some of the ways in which scientific knowledge has influenced and is influencing thought and the intellectual climate of the world. He believes that the quantum theory, for example, which had forced physicists, some of them very unwillingly, to believe that fundamentally the laws of physics are not statements of what must happen, but of the relative chances of a variety of alternatives, made quite a difference to the way one regards the universe, and that its consequences are still not realized by the average educated man. Yet these new ideas which science has provided, and is providing, new ideas tied closely to experience of a special character, constitute an achievement of which man may well be proud. It is surely something for beings, so utterly insignificant compared with the smallest of the stars that are scattered with reckless abandonment in the heavens, to be able to understand some at least of the principles which control their existence.

Sir George disclaimed any understanding of the relation between scientific concepts and reality, and some philosophers may well find the earlier part of his address provocative. It was not, however, the philosophy of science that he was concerned to display or the relations between science and philosophy; rather he sought to help some of those not closely concerned with science to understand something of the achievements of science in human thought, and the dependence of technological advance, or the increasing control over man's physical environment which technological achievement permits, on the advances in the fuller and deeper understanding of the physical world which science continually brings to us. "The full fruition of scientific work depends upon three things: the desire to know, the initiative to find out, and the awareness to apply"; in saying this in his tercentenary address to the Royal Society, Sir Cyril Hinshelwood recognized that scientific achievement is the result of the efforts of a small minority. Although Sir George Thomson did not attempt quite so large a canvas, his address is no less calculated to win the interest and assist the understanding of a wider audience in the work of men of science. What that small minority can achieve, either in the understanding or in the control of Nature, depends to some extent on the intellectual climate of its time, and the understanding and support it receives from the majority. The pursuit of knowledge should, as Sir Cyril implied, no longer remain the concern of the few; but, if the chronicler is to give more regular attention to the adventure and achievements of science, if the historian is to be induced to examine or record the interaction of scientific ideas with those of philosophy, politics or religion, much will depend on the determination and pertinacity, as well as the lucidity, with which men of science themselves seek to interpret the adventure of science in human understanding, no less than in extending our control of Nature to humanity in general. As Sir Cyril observed, the propagation of an idea demands the right conjunction of unknown human factors; but even when these are propitious, nothing will initiate the change save the operation of a minority, perhaps even beginning with an individual. But the majority and the individual are in mutual dependence for, except under rare conditions, the individual in isolation is impotent. To create mutual understanding and, it might be added, confidence, between the creative minority and the majority on which the minority is dependent for resources, is an essential task in science as in art; and Sir George Thomson's penetrating exposition of the relations between the two aspects of science—extension of human understanding of the world in which we live, and the enlargement of man's power of controlling the material forces and resources of that world—is best appreciated as an effective essay to that end.

## IONOSPHERIC PROPAGATION OF ELECTROMAGNETIC WAVES

### The Magneto-Ionic Theory and Its Applications to the Ionosphere

A Monograph. By J. A. Ratcliffe. Pp. x+206. (Cambridge: At the University Press, 1959.) 40s. net.

THE propagation of electromagnetic waves through a gaseous ionized medium in the presence of a magnetic field is a very complicated problem in its full complexity. It is fortunate that, for applications to the ionosphere, certain simplifications may be made. Thus it is rarely necessary to take explicit account of the wave character of the propagation—attention can be concentrated on the determination of the indices of refraction and of absorption. Even so, there is a great number of factors to take into account and it is extremely difficult to see how each is effective, as well as to be aware of all the different possibilities which can arise. It is therefore fortunate that one of the most skilful exponents of the subject has written this monograph with an eye always towards applications to the ionosphere.

The book is planned on a very systematic basis with the careful attention to detail which is so necessary in presenting this subject. On the other hand, the treatment is by no means purely mathematical. Indeed, special attention is devoted to discussing the physical significance of the various formulæ and approximations which are introduced.

The introductory chapter includes a historical account of the development of the subject, which is of

much interest and includes a summary of the nomenclature which is used consistently throughout the book. Part I is concerned with the derivation of the equations. Both macroscopic and microscopic approaches to the problem are described in successive chapters, special attention being directed in two following chapters to the discussion of absorption.

The equations obtained are complex, and Part 2 is devoted to a detailed discussion of this interpretation. A gradual approach to the most-general case is skilfully employed so that the maximum insight into the significance of the different contributory effects can be obtained. The successive chapters deal with the graphical representation when there are no collisions, the polarization of the waves, the quasi-longitudinal and quasi-transverse approximations, the effect of collisions on the indices, some representative curves of the indices, and the group velocity.

A similar gradual approach is used in Part 3, which deals with applications to the Earth's ionosphere. Thus Chapter 12 deals with a model ionosphere with no magnetic field, to be followed by one in which the effect of a magnetic field is included. The concluding chapter of this part gives an interesting account of the nature of the motion of electrons in the ionosphere in the presence of the Earth's magnetic field.

The last part deals with some miscellaneous subjects. Chapter 15 discusses the question of whether the Lorentz term should be included in the expression for the complex refractive index and Chapter 16 examines the effect of the presence of heavy ions. In Chapter 17 the restriction otherwise maintained of dealing with a homogeneous medium is lifted and many new effects which can then arise are discussed. The final chapter compares and contrasts the propagation through the magneto-ionic medium with that through an anisotropic medium such as a crystal. An extensive bibliography is provided.

This monograph is a masterly work written by a great expert not only in the subject but also of exposition. It cannot fail to be of great value to all who are interested in the ionosphere and related subjects. Its appearance at a time when new possibilities of research in radio propagation have been opened up through the use of rocket and satellites is most opportune.

H. S. W. Massey

## PROPOSALS FOR SPACE FLIGHT

### The Exploration of the Solar System

By Felix Godwin. Pp. 200+10 plates. (London: Chapman and Hall, Ltd., 1960.) 35*s*. net.

THIS book represents an attempt to outline the probable development of astronautics between now and the year 2100, with many detailed accounts of possible expeditions, based on the assumption that only currently foreseeable techniques are used. The first topic discussed is the near-Earth assembly orbit, which will serve as the base for space-ships; then the problems of instrumented and manned expeditions to the Moon are reviewed. Next there is a lengthy and detailed plan for the exploration of Venus, followed by a similar one for Mars. The main text ends with a long chapter on further possibilities, such as visits to the outer planets, plasma rockets and interstellar flight. Finally, there are several appendixes, on topics such as rocket propellants, personnel, space warfare and costs, a glossary and a full index.

Although inevitably there is much that is speculative in the book, the factual detail is piled up with such convincing realism that the reader is often persuaded to suspend disbelief. Many authors of books on space flight give the unfortunate impression that to travel enthusiastically is better than to arrive, but Mr. Godwin's expeditions have a clear aim—to make thorough scientific investigations of the planets—and travelling is merely the means to an end. The author writes in the present tense, as if all the complex operations he describes were matters of routine, and for him there is no gap between the possible and the practical. This might be thought a fault, and attributed to his youth—for he wrote the book between the ages of sixteen and eighteen. But in a book about the future, there would seem to be no harm in recognizing the truth that the technological impossibilities of one generation are the commonplaces of the next. It must be emphasized, too, that the author has voluntarily limited himself to foreseeable techniques: with the development of unforeseen ones, his plans may come to seem timid rather than over-ambitious.

Mr. Godwin evidently has a wide knowledge of most aspects of space technology and physics, but there are plenty of flaws to be found among the crowded detail of the book. His schemes, though ingenious and well thought out, are sometimes out of touch with present practice: for example, solar batteries are not mentioned except in a brief paragraph on p. 124, though power supplies are often discussed earlier. He relies too much on space-flight books of the early 1950's, some of which are now seriously out of date. His use of symbols is undisciplined; for example, the symbol $a$ on pp. 24 and 25 is not only undefined but has two different meanings. Pp. 74–76, explaining in detail the optimum manœuvre for a tanker intercepting a returning space ship, seem to be erroneous: the tanker's weight could be reduced by a factor of about 3 if the transfer were made near perigee. One could go on finding fault in this way, but such flaws do not destroy the book's real merit of providing a logical and well-founded outline of the probable future exploration of the solar system. The reality will, no doubt, be different, but only because of advances not yet predictable.

D. G. King-Hele

## GENERAL AND LINEAR CIRCUIT THEORY

### General Circuit Theory

By Prof. Gordon Newstead. (Methuen's Monographs on Physical Subjects.) Pp. vii+144. (London: Methuen and Co., Ltd.; New York: John Wiley and Sons, Inc., 1959.) 15*s*. net.

THIS book is a welcome addition to Methuen's series of monographs on physical subjects. Prof. Newstead has undertaken the ambitious project of outlining a general circuit theory in 140 small pages and has succeeded to a remarkable extent.

It might have been better to have expanded the book into two volumes, one for steady-state theory and the other for transient theory. The author would then have been able to develop his generaliza-

tions at greater length and his arguments would have been easier to follow. In its present form the book is scarcely suitable for those seeking an introduction to the subject and is more suitable for experts.

The starting point of the book is the linear differential equation for two terminal networks:

$$i = \Sigma_r a_r D^r e$$

where $r$ has zero, positive and negative integral values and $D \equiv \mathrm{d}/\mathrm{d}t$. The bulk of the book is confined to the treatment of the linear circuit theory following from this equation and Kirchhoff's laws. The author allows himself only ten pages in the last chapter to deal with non-linear theory, but gives here a most attractive presentation of the methods used for tackling non-linear problems. The importance of this ever-growing class of problems is scarcely underlined by such a meagre allocation of space, and it is to be hoped that another monograph from the same author will soon appear providing a generalized treatment of non-linear problems.

In the first three chapters of the present book the author develops from the above basic equation the concept of circuit components and then proceeds with the development of general network theorems and the treatment of the 4-terminal network in the steady state. There follows a chapter on "The Fourier Integral" and the treatment of network transients.

The book is mainly mathematical in character.

A. H. M. Arnold

## CHEMICAL PHYSICS COMES OF AGE

### Advances in Chemical Physics

Vol. 1. Edited by Prof. I. Prigogine. Pp. xi+414. 87*s*. Vol. 2. Edited by I. Prigogine. Pp. ix+412. 87*s*. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1959.)

DURING the past fifty years we have seen the development of several new branches of chemistry—physical chemistry, radiation chemistry, quantum chemistry. All of them were associated with the incursion of new physical techniques or mathematical theories, and their subsequent exploitation within the total framework of chemistry. Chemical physics is a very vigorous child, with parentage in physics and mathematics as well as in conventional chemistry. At the research-level it is well catered for by the American *Journal of Chemical Physics*, the British *Molecular Physics* and other journals elsewhere. But the time has come when no one can follow all its development. Review summaries are required. The 'baby' has come of age.

These two volumes follow the general style and format of other sets of "Advances in . . .". Each consists of a series of ten to twelve articles, written by someone working in a particular section of the field, and setting out the major developments in the preceding years. The articles are very varied in topic—from isotope effects in chemical kinetics, through the electronic description of atoms and molecules to nuclear quadrupole resonance and clathrate solutions. They also vary in length—from 15 pages on transport theory in binary liquid solutions to 116 devoted to what is probably the most complete account hitherto presented of the calculation of correlation energy in many-electron problems. Some of the essays are easy to read, such as Bright Wilson's account of the barriers to internal rotation; others, such as Kihara's on the non-additivity of intermolecular forces, are much more difficult.

Prof. Prigogine, who edits this series, has started well. His choice of authors is excellent, and the range of topics almost entirely suitable. One is tempted to say that there is now developing a rather clearer acceptance of what 'chemical physics' really is. It has been defined by no one, but has grown with the subject. It is not chemistry, because continually physical concepts and techniques are used. Nor is it physics, because the language and thought-forms of chemistry belong to it. It is an outlook—a way of looking at things—with a certain degree of austerity in its discipline (as befits physics) and a satisfaction with understanding a phenomenon, even when you cannot completely calculate it (as befits chemistry). It makes unashamed use of mathematics, yet the mathematics is never the *raison d'être*. There are as yet practically no university chairs in it: but its arrival (so well documented in these annual volumes) has probably made as much difference to chemistry as any development since the atomic theory. Long may we continue to look for convenient summaries of its progress, similar to these present ones.

C. A. Coulson

## MOLECULAR GEOMETRY

### The Determination of Molecular Structure

By P. J. Wheatley. Pp. vii+263. (Oxford: Clarendon Press; London: Oxford University Press, 1959.) 35*s*. net.

A DISCONCERTING modern trend which this book serves to underline is the increasingly divergent scientific outlooks of the workers in different branches of chemistry. They tend even to attach different meanings to the words they use. For many decades past the classical organic chemist has used the expression 'molecular structure' to denote the arrangement of atoms in molecules and the manner in which they are linked. Mr. Wheatley uses the term in the more precise sense of configuration and molecular dimensions. From this point of view he is no doubt justified in his reference to the "uncertainty attached to many chemical arguments" and in saying that "nowadays an appeal is almost always made to the more reliable physico-chemical methods". But the traditional chemical methods of determining molecular constitution are by no means obsolete, and there is no immediate prospect that they will soon be superseded.

To the theoretical chemist it may well be true that "the object of any scientific experimentation is the elimination of further experimentation". This is another respect in which the author's attitude is very different from those who pursue other branches of the science.

Mr. Wheatley's book gives a brief and interesting survey of modern physical methods used in determining the sizes and shapes of molecules. There are a section on spectroscopic methods (excluding ultraviolet absorption), a considerable section on diffraction methods (mainly X-ray diffraction of crystals but including also electron and neutron diffraction)

and a third section on miscellaneous methods, including dipole moments and nuclear magnetic resonance. The approach is theoretical rather than practical but care is taken to indicate the types of information that can be obtained by the application of the methods discussed. At the end of each chapter are useful references to more extensive publications on the subjects under discussion. J. W. Cook

## GENETICS OF CONTINUOUS VARIATION

### Introduction to Quantitative Genetics

By D. S. Falconer. Pp. ix+365. (Edinburgh and London: Oliver and Boyd, Ltd., 1960.) 35*s*. net.

THE genetical study of continuous variation has had a somewhat chequered career. To Darwin this was the variation that mattered above all, and it was the variation to which Galton and later Pearson devoted their unsuccessful efforts to work out the principles of heredity. To the early Mendelians, however, it was, one feels, a puzzle and even a nuisance, intractable by their techniques and a source of acid dispute. True, the basis for understanding its determination and properties was laid down during this period; but its experimental study was so much more tedious and its theory so much more mathematical that for several decades it just failed to hold its interest in the face of the more classical type of genetical study. Now the situation has changed again. The significance of continuous variation in wild populations and its key importance for plant and animal breeding are fully recognized, and the past fifteen years or so have seen a tremendous growth in its genetic study. Its problems and perhaps even more its analytical techniques may still set it apart as a somewhat specialized branch of genetics, but it is as essential to an appreciation of the science at one end as cell chemistry, deoxyribonucleic acid and gene structure are at the other.

Dr. Falconer has now given us a text-book of, as he terms it, "Quantitative Genetics", and we are indebted to him for it. It is a noteworthy book in several ways. To most biologists it will read more like a text-book of physics than like the type of biological literature with which they are familiar, so much is mathematics an integral part of the structure. Yet we should be grateful that the mathematics is never oppressively advanced or complex—a virtue which will be acknowledged the more readily by those who have attempted other texts in this field. Within its ambit it covers the ground admirably, and its length serves only to indicate the amount of ground to be covered. The behaviour of genes in populations, variation, heritability, selection, inbreeding and heterosis, particularly as they appear in animal experiments, are all dealt with lucidly as well as carefully: indeed in places, as where family selection is analysed and discussed, the treatment is of a notably high order. Occasionally a laxness of expression creeps in, as where it is said that the "partition of (phenotypic) variance into genotypic and environmental components formulates the problem of . . . the relative importance of genotype and environment in determining the phenotypic value"—surely one of the oldest *non-sequitur* in the history of genetics. At times, too, the argument is more than a little tendentious; but these periodical blemishes can weigh only lightly in the balance against the generally consistent quality of the book.

The risk of a book such as "Quantitative Genetics" lies elsewhere, in its very success in presenting the mathematically analytical approach. Mathematics has a charm of its own, in the clarity, generality and finality with which its conclusions emerge. These, however, can never be sounder than the evidence, postulates and concepts from which they are derived, and the charm becomes meretricious if it blinds us to the limitations of the situations, the complexities of the relations or the uncertainty of the premisses we are exploring. Dr. Falconer, for example, spends little time on linkage: he largely contents himself with reiterating the charge that mathematics has shown it cannot have much importance in relation to selection while ignoring the experimental evidence that it is in fact not so lightly to be dismissed. He discusses correlated response to selection wholly in terms of pleiotropy, which is easy to handle by correlation technique, but overlooks the cases where linkage supplies, to say the least, a much more satisfactory interpretation of the experimental results. He argues for a simple relation between heterozygosity and fitness but barely mentions the self-fertilizing plants which show that this relation must itself be the product of natural selection in the past. He states that the genes governing number of bristles in *Drosophila* show no dominance, and bolsters his contention that this character is selectively neutral by postulating hypothetical pleiotropic effects of these genes while supporting his view by reference to evidence which is at least as readily interpretable in the opposite way. In justice to Dr. Falconer it must be said that most of these opinions are to be found in the final chapter, which he himself describes as setting out his own views on controversial topics. This is a praiseworthy warning, for indeed whatever disagreement we may feel with these final sections should never be allowed to blind us to the great value of the other nine-tenths of the book, or to the debt we owe Dr. Falconer for so ably presenting the subject, especially as it appears to the animal geneticist, for the benefit of all our students. Kenneth Mather

## THE YELLOW FEVER MOSQUITO

### *Aëdes aegypti* (L)

The Yellow Fever Mosquito—Its Life History, Bionomics and Structure. By Sir S. Rickard Christophers. Pp. xii+739. (Cambridge: At the University Press, 1960.) 75*s*. net.

THE yellow fever mosquito is a most appropriate subject for a large treatise. Of all mosquitoes it is that most easily maintained in culture in the laboratory. Its most characteristic breeding site is the small tree-hole containing an ounce or two of water, very liable to dry up. The eggs stranded under these conditions can withstand desiccation for many months and hatch in a few minutes when immersed in water; abundantly fed, they reach the adult state in a few days. It is therefore a most valuable experimental animal upon which much of our knowledge of the physiology of mosquitoes in general has been based. It has been extensively used as a test object for insecticides and repellents.

Few insects have suffered more at the hands of taxonomists than this mosquito. It is now generally known as *Aëdes aegypti* Linnæus 1762. It may or

may not be the insect briefly described by Linnæus under that name—but after so many tiresome changes it is to be hoped that the name will stick. *Aëdes aegypti* occurs throughout the entire tropical belt around the globe, and extends for a variable distance into the subtropics. Throughout most of its range it is a domestic insect, rarely breeding more than a few yards from human habitations. It was incriminated by Reed and his colleagues (1900) as the carrier of urban yellow fever; it also carries the virus of dengue fever. It is therefore an insect of great importance to mankind.

The effective control of *Aëdes aegypti* in Havana and Panama, with the elimination of yellow fever, gave promise that the disease could be eradicated from the New World. But the attempt at eradication by the Rockefeller Foundation brought to light the existence of a sylvan form of the disease maintained by other mosquitoes in monkeys and other mammals in the jungle and spreading only occasionally to man, and so to his domestic mosquito. The same epidemiological pattern has been found in tropical Africa; and rural forms (genetic strains) of *Aëdes aegypti* have been recognized which can also be involved in the transmission of the rural disease.

As the years have passed the subject of yellow fever and its main carrier has become ever more complicated. It will be a great boon to have this erudite and practical treatise on hand, dealing as it does with all aspects of the morphology, physiology, biology and control of *Aëdes aegypti* (much of the morphology being original), written by an author who has been an authority on mosquitoes since he was a member of the Malaria Commission of 1899–1902, combining a sense of history with a good account of the most modern work, and beautifully produced. It will not be difficult to find small omissions of recent work, but it is to be doubted whether any other author could have written such a well-proportioned survey of this many-sided subject. It was a wise and generous decision of the Rockefeller Foundation to make possible the publication of this book.

V. B. Wigglesworth

## EMBRYOS OF BIRDS

### The Avian Embryo

Structural and Functional Development. By Prof. Alexis L. Romanoff. Pp. xvi+1305. (New York and London: The Macmillan Company, 1960.) 210*s*.

Some ten years ago, Prof. Romanoff, who holds the chair of chemical embryology at Cornell University, published in collaboration with his wife a massive compendium on the avian egg. He has now proceeded to a detailed consideration of the embryo within the egg. Embryos of the domestic fowl have been perhaps more widely and thoroughly studied than those of any other vertebrate. Romanoff's monograph is certainly the most complete that yet exists in this field. Moreover it covers the embryo not only of the fowl but also those of all other birds in so far as they have been studied. It is therefore an invaluable work of reference, and there can be no embryologist who does not feel a debt of gratitude to the author for the enormous labour which must have gone to its compilation.

Romanoff states that in the preparation of this book it was necessary to make a critical study of more than 7,000 original publications, about two-thirds of which were written in languages other than English. Of these only some 2,700 are cited in the text; but that is already a much more extensive bibliography than is available elsewhere. Moreover, the list of references is at the same time an author index, giving reference to the page of the text in which the work referred to is discussed. One perhaps slightly odd feature of the bibliography is that no mention is made of the other recent monographic works on the chick, such as Hamilton and Hamburger's revision of Lillie's book, the Willier-Weiss-Hamburger "Analysis of Development" or my own "Epigenetics of Birds". On the other hand, the references to original publications give evidence of truly catholic reading, and will be found particularly valuable by English-speaking readers to whom the contributions published in other languages may not be so easily available.

The first three chapters cover the reproductive cells (70 pages), fertilization and fertility (40 pages), and early morphogenesis (about 95 pages). In the last-named chapter it is particularly gratifying to see full accounts of the work of the real pioneers of the modern period of our knowledge of gastrulation and associated processes in the chick, such as Gräper, Wetzel and Pasteels, which in some of the recent American monographs has tended to be somewhat neglected in favour of more recent American work. The experimental studies on these stages has also been very well reviewed. It is perhaps noteworthy that Romanoff does not use, and so far as I can make out, does not even mention the conventional numbered stages into which the development of the chick embryo has been divided, for example by Hamburger and Hamilton. Personally, I find the use of such stage numbers an unnecessary impediment to ease of understanding. If one refers to an embryo as in the long streak stage, the head process stage, or the three somites stage, everyone knows immediately what is meant, whereas reference to stage 13 conveys nothing except to the expert and saves only a minimal amount of breath or printer's ink. However, many embryologists appear at the present time to favour the use of numbered stages, and it would perhaps have been valuable if Romanoff had at least listed them.

After these three introductory chapters there follow more than 900 pages devoted to the description of the development of the various organ systems, including the extra-embryonic membranes. It is clearly impossible to review these in detail; it can only be said that a vast body of information is here assembled together and that the choice and arrangement of materials show evidence of a good critical insight. A subject index of more than 60 pages in addition to the bibliography author-index make it possible for the reader to find his way about. The book also contains some 440 illustrations which comprise in all more than 2,250 separate drawings. In spite of the size of the book these have had to be reproduced on a comparatively small scale, but they have been re-drawn in a simple style so that nearly all of them remain quite clear even after reduction.

Both in the wealth of detail it includes and in the balance and fairness of its account, Romanoff's book is far in advance of any previous monograph on the bird embryo. It will certainly remain the standard work of reference in this field for many years to come.

C. H. Waddington

# ASPECTS OF PLANT NUTRITION

## Nutrition of the Legumes

Proceedings of the University of Nottingham Fifth Easter School in Agricultural Science, 1958. Edited by Prof. E. G. Hallsworth. Pp. x+360. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1958.) 55*s*.

## Utilization of Nitrogen and Its Compounds by Plants

Symposia of the Society for Experimental Biology, No. 13. Edited by H. K. Porter. Pp. vii+385. (Cambridge: At the University Press, 1959. Published for the Company of Biologists on behalf of the Society for Experimental Biology.) 50*s*. net.

THIS is an age of conferences, and both the Society for Experimental Biology and the Agricultural Department of the University of Nottingham can claim a high degree of success for those they organize in their respective fields of interest. In 1958 the topics of the Symposium of the Society for Experimental Biology and of the University of Nottingham Fifth Easter School in Agricultural Science overlapped considerably, for in a discussion on the nutrition of legumes, the subject of the latter, the uptake and utilization of nitrogen, the subject of the former, must obviously demand a leading, though by no means exclusive, part.

In the Nottingham Easter School the various aspects of legume nutrition were well covered by the twenty-four papers provided by the various contributors. These papers were classified in five groups: the plant component, the rhizobial component, the symbiotic system, biochemical aspects and field aspects. The papers in the first group, apart from one on the classification of the Leguminosae by Prof. Tutin, were concerned with mineral nutrition, particular attention being given to micronutrients and aluminium. Among the second group were contributions on the classification of *Rhizobia*, the physiology of nodule formation, the survival of the root nodule bacteria outside the host plant and a general consideration of the symbiotic fixation of nitrogen in the Leguminosae. The third group of papers was largely concerned with factors affecting the uptake of nitrogen by legumes and factors affecting nodulation, but included in this group was a paper by Dr. G. Bond on symbiotic fixation of nitrogen by eight genera of angiosperms outside the Leguminosae. The biochemical aspects considered in the fourth group were nitrogen fixation, the transport of amino-acids, and the effect of iron deficiency on amino-acid metabolism in the yellow lupin. The papers concerned with field aspects dealt with a rather miscellaneous assortment of topics ranging from the tolerance of lucerne to excess manganese and copper deficiency in the field to the growth of a clover sward.

In the Symposium of the Society for Experimental Biology the emphasis was mainly biochemical, as was to be expected when the theme was the utilization of nitrogen. The course of nitrate reduction and the enzymes concerned in it, various aspects of the metabolism of amino-acids, including their assimilation and utilization, the biosynthesis of amide and peptide bonds, the formation of alkaloids, and the relation of nucleic acids to plant growth and development, were among the subjects of the twenty papers contributed to the Symposium.

The papers presented at both these conferences varied considerably in respect to the amount of original unpublished information contained in them. It would perhaps be best to regard them as essays giving an up-to-date account of the respective subjects with which they dealt, written by experts actively working in their various fields. As such they provide a wealth of information on the nutrition of the Leguminosae and the utilization of nitrogen by plants in general.

The esteem in which these conferences are held and the value placed on them by the participants is indicated by the number of overseas visitors taking part. In the Nottingham School 40 per cent, and in the Society for Experimental Biology Symposium 50 per cent of the papers were given by workers abroad who came from Australia and New Zealand, Canada and the United States, Belgium, Holland, Denmark, Finland, Germany and the U.S.S.R. WALTER STILES

# PARASITIC HELMINTHS

## Medical Helminthology

By Dr. J. M. Watson. Pp. xi+487. (London: Baillière, Tindall and Cox, Ltd., 1960.) 84*s*.

TO summarize, in a convenient form, all the work that has been done in the past half-century on the human diseases caused by helminths is not an easy task; and when an author includes, as Watson does, references to diseases caused in other animals by these parasitic worms, the task is greater still. Watson has, however, had long experience of his subject. He was senior helminthologist to the Wellcome Laboratories in London, served as a member of the World Health Organizations' Expert Committee on Parasitic Diseases and has been professor of zoology and of parasitology and bacteriology in the University of Baghdad. The book he now gives us is based on lectures he gave at the American University of Beirut, and the manuscript of it has been checked by English, Canadian and American experts whose names are household words in the field of parasitology.

Part I of the book is a general introduction to the subject, which reviews the comparatively brief history of helminthology and discusses the zoological position of parasitic helminths, their relations with their hosts and the geographical distribution of the important species which infect man. In the bulk of the book (Part 2) the author gives an account of the helminths themselves, arranging these, not, as most text-books on this subject do, according to their zoological position, but according to the tissues which they attack. This is, the author thinks, clinically more convenient and no doubt many will agree. Others will prefer the zoological plan, which at least has the merit of bringing together the types of lesions caused by nematodes, cestodes and trematodes, respectively. The third part of the book discusses the diagnosis, treatment and prevention of helminth infections, and appendixes provide a bibliography, all too short, some may think, of key references to the vast literature, a valuable chapter on the rules of zoological nomenclature and another, which research workers will find useful, on the helminth infections of common laboratory animals. In his final chapter the author gives, among other facts, notes on the rapid recent advances in our knowledge of vectors and anthelmintics.

It is not possible, in a brief review, to discuss detail in a book as extensive as this one and, in any event, the criticism of detail is best left to the teacher or the research worker who uses the book and advises students about it. But a word must be said in praise of the 62 figures, most of which are made up of several individual line drawings, among which are silhouettes of parasitic helminths which give their natural size, a useful feature which appears in other books, but not to the extent to which it is here employed. The production of the book must also be praised; it is well printed, in clear type, in parallel columns on a large page and, unlike some very heavy text-books on this subject, it is delightfully light.

G. LAPAGE

## PLANNING FOR THE CHANGING WORLD POPULATION

### Our Developing World

By Prof. L. Dudley Stamp. Pp. 195. (London: Faber and Faber, Ltd., 1960.) 21*s*. net.

PROF. DUDLEY STAMP gave the Patten Foundation Lectures at the University of Indiana in 1950. These lectures were expanded and published in 1952 by the Indiana University Press and the American Geographical Society under the title "Land for Tomorrow", and were revised for the English edition "Our Undeveloped World", published in 1953.

Rapidly changing world populations, land-use values and food supply, urbanization, and new developments in farming, in mechanization of agriculture and in plant and animal genetics during the past seven or eight years have made further revision necessary, and "Our Developing World" now appears as a new book emphasizing the same fundamental point of view of the author on the ever-increasing pressure of population on land resources and incorporating, where appropriate, much material from the two earlier books, but also bringing new thought to the problems of under-developed lands.

At the present rate of increase, world population will be doubled in less than forty years. This problem and its related one of planning land use are considered on the world-level, the national level with extremes of wealth in some countries and poverty in others, the regional level and local level. Farming is rapidly becoming a specialized industry. The proportion of population engaged in farming is decreasing almost all over the world, and while the movement is generally away from subsistence farming to commercial agriculture it must not be assumed that increasing industrialization and decreasing agriculture are necessarily the panacea for all ills associated with under-development.

Increasing urbanization is a pressing problem, and growth of cities cannot easily be limited. Efforts should be directed towards improving the urban environment as part of a correct land-use programme. The need for mapping the present distribution of population is as important as that for mapping the use of land, and a Commission has been set up by the International Geographical Union for the study of this problem. The geographical distribution of pests and diseases in man, animals and crops is another contributory study to population and land-use problems.

Prof. Dudley Stamp's conclusions are that world starvation is not just around the corner, that the population of the Earth could be increased to many times its present number without starvation provided man-made barriers are broken down and food is produced efficiently by a comparatively small number of specialist farmers.

M. K. MILNE

## CONTINUITY IN A SMALL PACIFIC ISLAND

### Social Change in Tikopia

Re-Study of a Polynesian Community after a Generation. By Raymond Firth. Pp. 360+8 plates. (London: George Allen and Unwin, Ltd., 1959.) 45*s*. net.

TIKOPIA is an isolated speck of land seven miles in circumference with a population of fewer than 2,000 souls; it is one of the smallest of the small islands on the periphery of the British Solomon Islands Protectorate, of which entity it has been politically since 1898 a remote outlying fragment. The nearest land is another islet, Anuta, 70 miles to the north-east; the nearest administrative officer of the Protectorate resides at Vanikoro in the Santa Cruz Group, 130 miles away; it is 500 miles distant from the Solomon Islands proper.

This dot in the Pacific Ocean is inhabited by a community of Polynesians left behind during the great migrations that led the main branches of the race on to Samoa and Tonga, the Ellice and Cook Islands and Tahiti, to Hawaii in the north, New Zealand in the south and Easter Island in the far east of the Pacific. Cut off since those migrations from the centres of Polynesian life, the people of Tikopia and of the other islets in the Solomon Islands' "Polynesian Fringe" have continued to live in isolation as they had always lived; even in the first half of this century they were seldom visited more than about once a year by a Mission ship or a government officer. Before the Second World War, practically no Tikopians ever left their island (except perhaps for a temporary sojourn in Anuta) to return with new ideas from the outside world of other Pacific islands, for a paternal if distant Government wisely forbade recruiting-vessels to take them away to work elsewhere.

Tikopia was therefore the perfect subject for a detailed anthropological study; and in 1929 Prof. Raymond Firth concluded a long and solitary residence with this small, homogeneous and hitherto unchanged community; the principal findings of his study were published as a substantial volume in 1936 under the title "We, the Tikopia". After an interval of twenty-three years he decided to re-investigate the Tikopians (on this occasion in the company of a colleague) partly "to throw some further light on the analysis of the dynamics of small-scale integral social systems", but more particularly to ascertain what had happened to these hitherto sheltered islanders in a period that had seen, owing largely to a world war, such drastic changes in other parts of the Pacific.

What did he find? The first and most obvious impression was the sad destruction wrought by a hurricane shortly before his return, with its resultant grave reduction of foodstuffs and threat of famine. He then found, as he pursued his investigations, that the War had left Tikopia alone since, luckily for its

people, it was off the line of the Solomon Islands campaign. The Tikopians, he says, "were spared the traumatic experience of most other islands; neither the Japanese nor the Americans established a base there".

But he also found that a few of the islanders had, after the War, gone to work in the Solomon Islands proper; that the people's geographical notions, previously more or less confined to Anuta and perhaps Vanikoro, had consequently received a modest expansion, that Christianity as taught by the Anglican Melanesian Mission had increased its majority over paganism, that money was beginning to co-exist with barter.

When Prof. Firth first resided in Tikopia, the men of the island presented a striking appearance of a bizarre and unique kind; tall, slim and well-built, they grew their hair as long as possible and bleached it with applications of lime to a golden shade, so that at a distance they seemed to be maned like lions. This was still the case when I myself visited the island more than a decade later, just before war came to the Pacific. On his return, Firth found that most of the younger men were wearing their hair short, and that some of the canoes that came out to meet him were paddled by exclusively female crews, "a striking cultural novelty".

Tikopia is too distant from any Government centre and too small for direct administration, even if this were thought to be suitable. Thus, the traditional local forms of autonomy have had the chance to survive; and Prof. Firth thinks that, even with increasing contact with the Government, the power of the chiefs is likely to grow so long as the Government accepts their authority. "With the clearer emergence of the Tikopian Chief as a secular power, recognition of him as such by the Government is likely to consolidate his general status".

Some artists—Tintoretto, for example—work on a vast canvas; others choose the technique of the miniature. Prof. Firth, in his two major books on the Tikopians, belongs to the latter class. He has devoted an appreciable period of his life to the study of a tiny community—1,200 souls during his first stay, 1,700 on his return—and he has dealt with it in the utmost detail. He has done well to do so, for Tikopia is not only, as he points out, "a highly structural society" but it is also a homogeneous one, saved by its geographical isolation from the drastic and sometimes disastrous changes that the Second World War has wrought in other primitive communities. He has, by this full account of his return to the scene of his former studies, conferred a benefit on all students of the Pacific. H. C. Luke

## FACT AND OPINION

### The Anatomy of Judgment

An Investigation into the Processes of Perception and Reasoning. By Dr. M. L. Johnson Abercrombie. Pp. 156+7 plates. (London: Hutchinson and Co. (Publishers), Ltd., 1960.) 25*s*. net.

THE author of this short book is a zoologist who has been much concerned with the selection and training of medical students. As a university teacher, she had become increasingly sceptical about the effects of an ordinary scientific education upon the capacity to think, and was therefore led to embark upon a most courageous experiment in education. This, essentially, was a free discussion class in which a dozen or so students were tactfully prevailed upon to scrutinize their own processes of observation and inference. For example, a discussion built around the incidence of 'observer error' in the interpretation of radiographs served to bring out the role of hidden inferences in the reporting of 'facts'. Other discussions were concerned with the meanings of words (for example, the word 'normal' as used in biology or medicine), with the rationale of classification and the evaluation of evidence. These classes were certainly not meant to provide formal instruction in logic or scientific method. Rather was it hoped that the participants, by gaining insight into their own preconceptions, would gradually attain a more original and genuinely objective approach to scientific issues. Although it is difficult to be sure, there is reason to believe that the new method achieved a very fair measure of success.

Although mainly concerned with cognitive issues, Dr. Johnson Abercrombie clearly finds it essential to devote some consideration to factors of temperament. Indeed she has gone out of her way to learn something of the techniques of modern psychotherapy and traces a most interesting parallel between her discussion classes and group psychotherapy. In both settings, discussion of topics apparently impersonal may serve to uncover insecurities at a deeper level. It follows, therefore, that educational experiments of the kind Dr. Johnson Abercrombie describes are not to be undertaken lightly. None the less, if we are to make the best of scientific education, it seems essential that we should discover ways to liberate the student from the security of his accepted patterns of opinion and thought. Dr. Johnson Abercrombie's work is at least a first step in this direction and, after all, *c'est le premier pas qui coute*.

Dr. Johnson Abercrombie's experience has stimulated her to inquire seriously into the psychology of perception and judgment and to attempt to place her findings within a broader psychological context. Indeed, the first part of her book provides a useful review of modern work in this field, with particular reference to the parts played by attitudes and experience in governing perceptual activity. Although her account is quite well done, it cannot perhaps be said to add anything to the numerous accounts of the subject already available. The value of this book lies above all in the description given of a fascinating real-life experiment and in its very real implications for the theory and practice of education.

O. L. Zangwill

## FRANCIS BACON WITHOUT HIS BACKGROUND

### Francis Bacon

The First Statesman of Science. By J. G. Crowther. Pp. xv+362+7 plates. (London: The Cresset Press, 1960.) 35*s*. net.

THIS big book falls into two parts. The first, "For Mankind", is an attempt to estimate Bacon's scientific achievement. The second part, "For Himself", offers a biography of the statesman. The suggestion here, that Bacon was in politics for private ends, is unfortunate, and does not really represent Crowther's view. For he has written a full and sympathetic study of Bacon's public career, which can be read with pleasure and is, in my judgment, the more successful portion of the book.

Of the first part it is not possible to speak so favourably. The character and the greatness of Bacon's reform of knowledge can only be brought out by a strictly historical approach. Before he could clear the path for an active philosophy of Nature, Bacon had to break the fetters of the past. These, in his view, were a Christian tradition which had belied its promise by sinking into resignation; a Greek tradition which had been entangled with Christianity by both the Scholastics and the Neo-Platonists and had made it still more helpless in the face of Nature; a magical and alchemical tradition which had kept alive the dream of a conquest of Nature but was vitiated by imposture, obscurantism and vain-glory; and a rhetorical and literary culture divorced from the manual arts. How Bacon fought and routed these doughty adversaries is a story until recently very imperfectly understood; but it was brilliantly elucidated four years ago by Prof. Paolo Rossi, of Milan, in his "Francesco Bacone: della magia alla scienza". Crowther is not alone among British scholars in ignoring Rossi's book; but he has done so at his peril. It is the only large-scale advance in Baconian studies since Spedding and Ellis.

Crowther's approach is unsystematic and unhistorical. He makes no serious attempt to describe the corpus of Baconian writings, to characterize the items, to date them, or even to list them completely. He does not seek to place them in their context in contemporary European culture. His method is to bring out of the Baconian hat one topic after another, illustrating it by quotation or free paraphrase but never indicating its source. To check him on any point would involve an endless chase. The chief aim of his study is to direct attention to any advance in modern science which can plausibly be regarded as a late flowering of some Baconian seed of thought. This, though not valueless, is a treacherous game. It is not what Pavlov or Sherrington did in the twentieth century that makes Bacon great. It is what Bacon himself did in the seventeenth. This the reader will not find in Crowther's book, for it can only be exhibited against a background which he does not supply.

B. Farrington

## BRIDGING THE GAP BETWEEN SCIENCE AND CHRISTIANITY

### The Spiritual Crisis of the Scientific Age

By G. D. Yarnold. Pp. 207. (London: George Allen and Unwin, Ltd., 1959. Published for the Sir Halley Stewart Trust.) 18s. net.

By and large, Mr. Yarnold's book could be described as a dissertation upon the theme of General Smuts's presidential address to the British Association at its centenary meeting, that man's material progress has outstripped his moral and spiritual advance and that advances there are imperative if man is to regain control over events. Dismissing as irrelevant any idea of a conflict between Christianity and science, Mr. Yarnold seeks to indicate what that relationship could be in the modern world and its bearing on the far-reaching crisis, essentially spiritual in character, through which the world is passing, largely because of its inability to assimilate new scientific knowledge and to direct rightly the new technical skills. In effect, the book consists of three essays, the first of which discusses the crisis of understanding which arises in considering the order of Nature, the second the crisis of belief which confronts us in considering scientific presuppositions and some of the central doctrines of the Christian faith, and the third the crisis of living involved in the ethical and moral problems of the nuclear age.

These three aspects are linked by the logical connexion between knowledge, belief and practical activity and the underlying insistence that the danger confronting civilization to-day arises primarily from the refusal to confront spiritual issues. Mr. Yarnold writes reasonably but persuasively. He suggests in his first essay that to bridge the gap between the sciences and Christian theology we need ask no more than the acceptance of three simple integrative principles: the external world is not self-existent, but is created by God; in studying the external world by the method of the sciences, the human mind makes contact with the divine mind—thus discovery and revolution are two aspects of the same encounter; and the fundamental laws of Nature are what they are because God has so ordered the world which He has created. In his second essay he presents his reasons for believing that in its essentials the Christian tradition has been preserved with commendable accuracy, and while he recognizes the difficulties which the modern scientific outlook places in the way of full Christian belief, he himself holds that faith with intelligence as well as with conviction.

Even those who are unable to go all the way with Mr. Yarnold in these interpretations of the world of Nature and of the Christian faith may well agree with him in much that he writes about the crisis of living. No argument as to how far the ethical standards for which he pleads can be truly described as Christian ethics can invalidate a penetrating analysis of the bearing of respect for human personality and the values which characterize the teaching of Christ on the problems of living that arise in the world to-day. The acuteness of such problems is largely due to our failure to notice the human problems created by technology until those problems have become unmanageable. It is not the emergence of entirely new moral problems but the extraordinarily rapid increase in the power which the new knowledge has placed at man's disposal: man's power has outgrown his moral capabilities.

On many of the varied aspects of the problems that arise in this situation Mr. Yarnold writes with insight and sanity, and this essay could well be read with profit by many who might be disinclined to follow him in the two preceding essays. Particularly on the industrial society he is trenchant and displays the critical issues, and on nuclear power and defence he has words which might well be pondered by some of the advocates of unilateral action who are inclined to overlook a government's responsibility to protect the lives and property of its nationals. Mr. Yarnold may not carry all his readers with him in his allegiance to Christianity, but he should at least be sure of their support in the moving appeal of this essay to bring all the moral and spiritual resources at our disposal to combat unprincipled private personal gain and human injustice which to-day technical knowledge and skill have often enabled to flourish on an unprecedented scale. Mr. Yarnold has at the least focused attention on some of the fundamental issues of our time as well as on the relations between the natural sciences and the Christian faith with dignity, sincerity and scholarship.

R. Brightman

# NEW HORIZONS IN CHEMISTRY*

By Sir ALEXANDER TODD, F.R.S.

ORGANIC chemistry is one of the most remarkable of all the sciences, and is usually regarded by the layman as one of the most abstruse and remote from everyday life and thought. This view is, perhaps, based on its content of jargon and its use of abbreviated molecular formulæ as a kind of hieroglyphic script. It is difficult to believe, however, that a science can properly be described as abstruse which permeates almost every material aspect of modern civilization, which stands as the bridge which links the physical with the biological sciences, and which is, perhaps, the biggest of the sciences in its factual content and in the number of its adherents. Organic chemistry is, perhaps, the most logical of the sciences, and in its history of about 150 years it has suffered fewer theoretical upsets than other sciences. It is a remarkable fact that the whole towering edifice of the subject rests essentially on three basic concepts propounded in the third quarter of the nineteenth century, namely, the concept of fixed combining power of valence due to Frankland, the Kekulé–Couper theory of the tetravalency of carbon and the capacity of carbon atoms to join together into chains and rings, and the theory of the tetrahedral carbon atom due to van't Hoff and Le Bel which gave us stereochemistry. All these concepts were purely empirical, but they have stood the test of time, and on them the whole of modern organic chemistry rests; advances in theory have occurred since they were first enunciated, but these have been essentially refinements giving more precise meaning to them and have in no way upset or destroyed their validity. I doubt whether the same claim could be made of any other science.

There have been two definitions of organic chemistry. Historically, the first, due to Berzelius, was "the chemistry of substances found in living matter". The second, commonly ascribed to Gmelin, appeared first about fifty years later when more was known about the peculiarities of the substances found in living matter and was simply "the chemistry of the carbon compounds". Each of these definitions is valid; but neither is wholly satisfactory, since the first is too restricted and the second is in certain respects too general. A very large number of known carbon compounds are of purely synthetic origin and do not, so far as we are aware, occur in living matter; but it is undoubtedly true that the study of substances which are found in living organisms has provided most of the major stimuli to the advance of organic chemistry throughout its history, and there is little reason to believe that this will not continue to be the case. After all, it was Pasteur's work on the tartaric acids from wine that led to the van't Hoff–Le Bel theory, the anthraquinone dyestuffs stem from Graebe and Liebermann's work on alizarin from madder root, and work on polymerization and plastics goes back to the studies of Harries on natural rubber. Many other examples could be quoted, but I shall mention only one other because it is probably not very well known. It was the work of Windaus on the isomeric sterols that influenced Hückel to develop his theoretical studies on stereoisomerism in fused ring systems and through this developed in the fulness of time a realization of the deep significance of conformational analysis in reduced ring systems—beginning with Hassel and developed by Barton and others—and with it the concept of a new dynamic aspect of stereochemistry which has in recent years exerted a profound influence over a very large area of organic chemistry.

The direct study of substances present in living matter—broadly described as natural products—in the sense of their structural elucidation and total synthesis, has been a dominant feature of organic chemistry only during the twentieth century. That it was not so during the past century can be readily understood, for without an extensive knowledge of carbon chemistry, the relatively complex natural products could not be successfully investigated. The nineteenth century was indeed essentially the period during which the necessary facts of carbon chemistry and the techniques of experiment were developed to the point at which natural product chemistry could be tackled with real prospect of success. This is not to say that natural products were wholly neglected in the nineteenth century; the medical importance of many of them ensured that some attention was paid to them, and, indeed, it was through such work that physiological chemistry and, in due course, biochemistry developed. To-day, with the development of natural product chemistry, it is interesting to see how the demarcation between organic chemistry and biochemistry is again becoming blurred—and with considerable advantage to both sciences.

Not only science as a whole, but also individual sciences, tend to advance irregularly on a broad front, and during any one phase of development there are always individual investigators who stand apart and who break new ground or who see new vistas or horizons not apparent to others at the time. For this reason it is difficult—especially with recent events—to put precise dates to changes in scientific patterns. But in broad terms it seems to me that during the first thirty years or so of the present century most organic chemists dealing with natural products were preoccupied almost entirely with the structure of compounds, while the biochemists were interested essentially with their function. During this period the organic chemists developed their methods of degradation and synthesis to a high degree of perfection and, aided by the introduction of new physical methods of analysis, they have taken them to the point at which the synthesis of molecules as complex as cholesterol, strychnine, chlorophyll, and a number of the coenzymes, has been realized. But since the mid-thirties, slowly at first, but later with increasing rapidity, interest has been moving to a study of structure in relation to function among natural products. It is this which has taken organic chemistry much closer to biology than it has ever been before. Equally, of course, it is the increasing realization that function must be considered in relation to structure that is bringing the biochemists closer to their organic chemical colleagues, to the advantage of both. The way in which organic chemical, biochemical and biophysical studies interact and illumine one another has been one of the

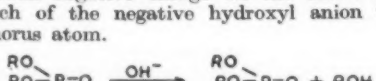
* Substance of a Royal Society Tercentenary Lecture delivered on July 20.

features of recent scientific advances in a variety of fields of biological interest, and it seems to me that it might be fitting to try to illustrate some of the new vistas that are opening up by giving a very brief outline of what has been developing in a few fields apparently diverse from a biological point of view, but which have a common chemical thread. It would be possible to choose a series of random topics to illustrate new horizons; but it is perhaps more instructive to choose a small group where the chemical background is common, and I confess that it is also more interesting to me to choose one where the common background is one with which I myself have been associated, namely, the chemistry of the organic phosphates.

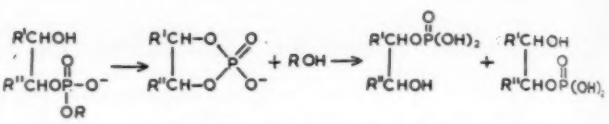
It has long been known that organic phosphates are invariable constituents of living organisms and that they have a variety of roles involving energy transfer and the facilitation of both synthetic and degradative processes in biological systems. Just how or why they do so and why phosphate should be found in such complex molecules as, for example, the nucleic acids and phospholipids, has been very much less clear. Until quite recently, organic chemists had paid very little attention to the synthesis or to the study of the chemical behaviour of organic phosphates, and in the absence of knowledge on these points much careful biochemical work remained without a satisfactory explanation.

My own interest in this field was aroused just over twenty years ago. I had been introduced to the study of vitamin structure by the late Prof. G. Barger, and this at a time when the relation of several of the B group of vitamins to the so-called nucleotide co-enzymes was emerging and the features which these latter had in common with breakdown products of the nucleic acids was becoming clear. The chemistry of the nucleotides was at this time in a rather rudimentary state and I began a series of investigations aimed at the clarification of this field by synthetic methods, including as a necessary part of it a study of the neglected field of phosphorylation and the study of organic phosphates. Over the years, through the efforts of many devoted and enthusiastic colleagues, we were able to make substantial progress in our general field of endeavour, but I propose to mention here only three features of the work which has been carried out. Each of them is really quite a simple and straightforward piece of phosphate chemistry, but each has a relevance to much wider problems which stand in the forefront of modern organic chemistry and biochemistry. I shall deal with them in turn, endeavouring to show in each instance their importance.

(1) *Hydrolysis of phosphates.* The neutral triesters of phosphoric acid are readily hydrolysed by alkali to the diesters; but the latter are normally resistant to further hydrolysis by alkali, presumably because the formal negative charge on the anion hinders approach of the negative hydroxyl anion to the phosphorus atom.

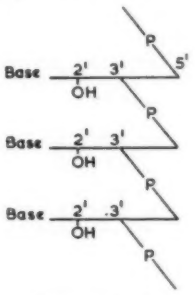



There is, however, one type of phosphodiester which does not show this resistance and which is, indeed, very easily hydrolysed by alkali. The characteristic feature of this type is that one of the esterifying groups bears a *cis*-hydroxyl in the α-position.

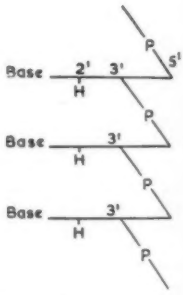



In such cases the spatial proximity of the hydroxyl group permits attack on phosphorus despite the negative charge on the anion, and we get very easy hydrolysis *via* a cyclic intermediate, the phosphoric acid residue invariably remaining attached to the glycol residue. Equally, of course, and for the same reason, phosphotriesters containing a *cis*-α-hydroxyl are even more easily hydrolysed than those which do not.

The recognition of these properties of organic phosphates was, in fact, the key to the understanding of the structure of the nucleic acids. The two types of nucleic acid—the ribonucleic acids and the deoxyribonucleic acids—are poly-diesters of phosphoric acid consisting of a large number of nucleosides joined together by phosphodiester linkages. These nucleosides are, in the case of ribonucleic acid, ribosides and, in the case of deoxyribonucleic acid, deoxyribosides, of heterocyclic bases. The conclusion that the nucleic acids are linear polyesters with a recurring 3′ : 5′-internucleotidic linkage, as propounded by Brown and Todd in 1951, rests essentially on their recognition that the behaviour of ribonucleic acid towards hydrolytic agents is that of a phosphodiester containing *cis*-α-hydroxyl groups, whereas deoxyribonucleic acids have the stability of a normal phosphodiester.




Ribonucleic Acid



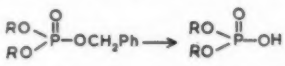

Deoxyribonucleic Acid

The recognition of the chemical structure of the nucleic acids paved the way for the brilliant biophysical and biochemical achievements of recent years in furthering our understanding of the key position occupied in all living matter by these substances and of the nature of the genes and viruses; and through these achievements there is opening out a wide vista of problems where the organic chemist must play his part—the reasons for specificity in polynucleotides and the determination of nucleotide sequence, the mechanism of protein synthesis and the use of template mechanisms, and the fascinating, if still distant, goal of the synthesis of specific polynucleotides.

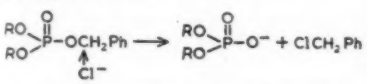
Before leaving the subject of hydrolysis of phosphate esters of glycols, it is worthy of note that this same structural feature is characteristic of the phospholipids. Investigations on these important substances based on an understanding of phosphate chemistry by Brown and others is now leading slowly to a clarification of the apparently confused chemical

and biochemical literature stemming from earlier investigations.

(2) *Anionic debenzylation of phosphates.* In the course of synthetic studies on organic phosphates and polyphosphates it was found necessary at times to be able to remove one benzyl group from a phosphotriester to yield a diester without recourse either to hydrolysis with alkali or acid or to hydrogenolysis, that is, to bring about the simple change:

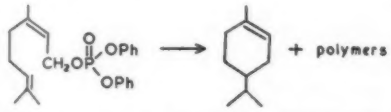


In such phosphotriesters the $CH_2$ of the benzyl group is strongly electrophilic (electron-deficient), the influence of the phenyl group being reinforced by that of the phosphorus atom. It is thus readily attacked and removed by anions, debenzylation being thereby effected.



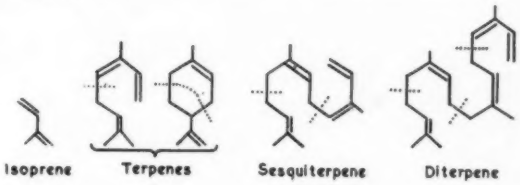
It is not, indeed, necessary to use an actual anion to bring about this reaction, although it is usually convenient to do so in the laboratory. Such compounds as tertiary bases are also effective because of their nucleophilic properties. Nor is the reaction confined to benzyl groups; allyl groups are equally easily removed and, provided that the other two groups *R* in the triester are such (for example, phenyl)

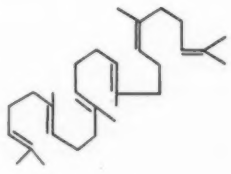
as to make the anion $(RO)_2P{-}O^-$ very stable, even alkyl groups can be readily removed by anionic fission. An example of considerable interest in connexion with the relevance of these observations to the function of phosphates as biosynthetic intermediates is the observation of my former colleague, Dr. Atherton, that geranyl diphenyl phosphate, in which the nucleophilic olefinic group is, or can be, spatially close to the phosphate group, undergoes cyclization (and also more complex polymerization) with very great ease.

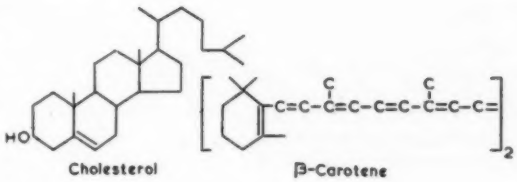



Organic chemists have long been fascinated by the structural relationships between many natural products and have assumed that compounds of one class, for example, terpenoids or alkaloids, are produced in different organisms by essentially similar synthetic processes. Interest in such topics has grown steadily since the early theory of alkaloid biogenesis from amino-acids due to Robinson, and his synthesis of the alkaloid tropinone from simple intermediates in dilute aqueous solution at room temperature under *p*H conditions similar to those commonly obtaining in biological systems. Biogenetic theories of this nature were based on chemical structural relationships and did not purport to set out in detail the precise mechanism of biosynthesis, and it was, perhaps, the failure to realize this which led to their neglect by some biologists and their too uncritical use by some chemists. But properly used, these theories have been, and still are, of immense value in the determination of structure of natural products. During the past twenty years or so the increasing availability of isotopes, both non-radioactive and radioactive, and the development of methods for incorporating them into organic compounds and following the fate of 'labelled' atoms in biological systems, has led to a joint effort by organic chemists and biochemists to elucidate the actual course of biosynthesis of complex molecules in Nature. In this field beautiful work has been carried out by many workers—by Schoenheimer, whose early pioneering work with nitrogen isotopes showed the way, and later by Bloch, Cornforth, Lynen, Shemin, Birch, and others—and in several fields we have now a good deal of precise information available. It should be emphasized that, while this new work has been gradually revealing the course of biosynthetic processes, it has also served to vindicate the organic chemist's use of biogenetic theory in his structural studies. I should like to say something about the mechanism of the biosynthetic pathways to the terpenoid and steroid groups of natural products, since this provides a particularly striking example of the relation between the 'biogenesis' of the organic chemists and 'biosynthesis', and also indicates, again through a consideration of phosphate chemistry, a broad field of further endeavour.

The name terpenoid is applied generally to a large family of natural products of which the simplest members, the terpenes of formula $C_{10}H_{16}$, are common constituents of the essential oils of plants. More complex members include the sesquiterpenes, $C_{15}H_{24}$, the diterpenes, $C_{20}H_{32}$, and the triterpenes, $C_{30}H_{48}$, together with related alcohols, acids, etc. Closely related to them in structure are the carotenoids and the steroids. It was Ruzicka who emphasized the biogenetic relationship of the terpenoids and showed that, so far as their carbon skeleton was concerned, they could, in general, be regarded as made up to 2, 3, 4 or 6 units of isoprene joined most commonly head to tail.

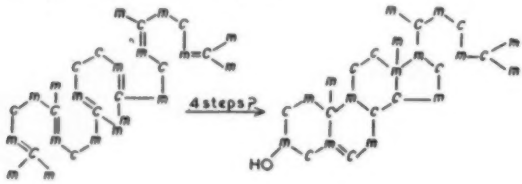


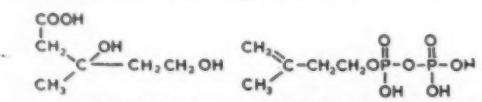
The basis of the isoprene rule can be readily appreciated from the sample formulæ given, and it has been of enormous value in chemical work. The relationship of the steroids to the other terpenoids is, perhaps, not quite so obvious from the formulæ, although it was first postulated just about thirty years ago on biogenetic grounds. The isoprene rule does not purport to portray the biosynthetic mechanism, although it certainly suggests that, even if isoprene itself is unlikely to be the synthetic intermediate in Nature, some closely related substance is likely to be involved.

The unravelling of the actual biosynthetic pathway to the terpenoids and the steroids is one of the outstanding achievements of recent years. True, there are some details still to be clarified; but, thanks largely to the magnificent work of Bloch, Cornforth, Lynen and their colleagues, the general picture is now clear. I do not propose to discuss the development of their work in detail, but will try to give a brief general outline. It really begins with the finding that the cholesterol molecule, and also the triterpene squalene, can be built up in living organisms from acetic acid—this was demonstrated by the administration of isotopically labelled acetic acid and elegant degradative studies on the cholesterol produced. Thus, we know that in the rat the cholesterol produced has the structure shown below, in which *m* represents a carbon atom from the $CH_3$ group of acetic acid, and *c* a carbon atom from the COOH group. It was next found that squalene is an intermediate in the synthesis of cholesterol, that is, that it is quantitatively converted to cholesterol by the rat. This conversion proceeds in several steps beginning with the formation of lanosterol—although all the intermediate steps have not been unequivocally fixed as yet.



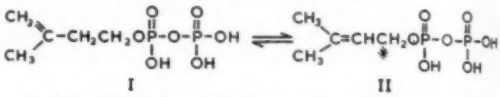

Squalene Cholesterol

So far so good—but what goes on between acetic acid and squalene? What is the hypothetical 'active isoprene unit'? It is now known that acetic acid is first converted in several steps to the six-carbon compound, mevalonic acid, and that this seems to be converted, through its phosphate ester, to *iso*pentenyl pyrophosphate, which has been isolated from biological systems and identified by analysis and synthesis. *Iso*pentenyl pyrophosphate is, in fact, the active isoprene, and from it stem the terpenoids, the steroids, the carotenoid pigments, and rubber.



Mevalonic Acid *Isopentenyl Pyrophosphate*

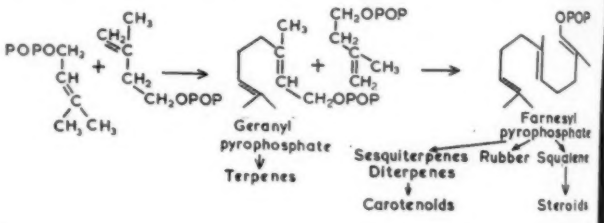
The mechanism of synthesis from *iso*pentenyl pyrophosphate is readily understood from our knowledge of the fission of benzyl and allyl esters of the phosphoric acids by anions and other nucleophilic reagents. *Iso*pentenyl pyrophosphate (I) can, like other similarly constituted compounds, isomerize to ββ-dimethylallyl pyrophosphate (II)—and, indeed, the two isomers may exist in equilibrium.



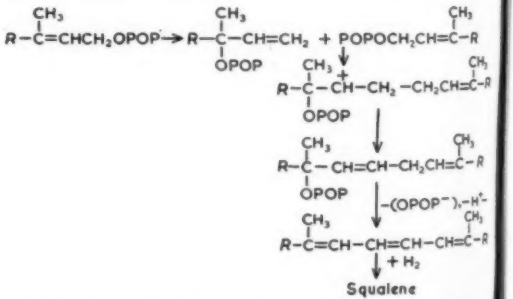
I II

In form II we have an allyl ester capable of attack at the asterisked carbon by a nucleophile (assuming that the ionization of the pyrophosphate residue is sufficiently depressed so that approach of the nucleophile is not inhibited), and in form I the unsaturated *iso*pentenyl group provides a nucleophilic centre. Reaction between the two forms will therefore occur precisely as in the case of geranyl diphenyl phosphate studied by Atherton.

In this way, from two molecules of 'active isoprene' we obtain geranyl pyrophosphate, from this, with another molecule, farnesyl pyrophosphate, and hence, by various routes, the whole range of observed natural products. It should be noted that such intermediates as farnesyl pyrophosphate have, in fact, been isolated and that it is possible, by using an appropriate enzyme system from rubber trees, to make a product indistinguishable from natural rubber starting with synthetic *iso*pentenyl pyrophosphate.



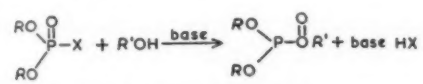

It is noteworthy that the conversion of farnesyl pyrophosphate to squalene involves a doubling of the molecule, since the latter is symmetrical; the same is true of the conversion of the diterpene intermediate to give carotenoids. As has been pointed out by Cornforth, this can be readily explained by the so-called farnesol-nerolidol isomerization of the pyrophosphates followed by the same type of nucleophilic fission as before.



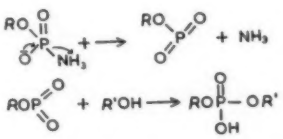

There are still points of detail to be settled in this fascinating story; but the broad picture is there, and from it opens out a new picture of synthetic mechanisms in Nature. Not only can one now begin to picture other biosynthetic processes involving phosphate intermediates, but, as I have already

stressed, the essential validity of the biogenetic concepts of the structural chemist receives, through this elegant work, a striking confirmation.

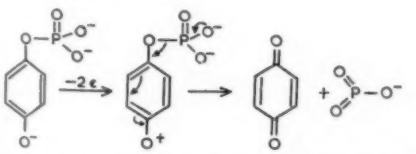
(3) *Oxidative phosphorylation*. Extensive research on the synthesis of phosphates and polyphosphates has led to the development of a variety of phosphorylation methods which fall essentially into two groups. In the first group fall those methods normally based on agents which can be regarded as derived from diesters of phosphoric acid and which proceed by expulsion of an anion.



In methods of the second group, to which some of the most powerful procedures belong, the active agent usually derives from a monoester of phosphoric acid, and instead of an anion a neutral molecule is expelled—for example, in the phosphoramidate carbodi-imide and imidoyl phosphate methods and in oxidative procedures. Much evidence exists for our view that in these cases the active agent in the phosphorylation is the hypothetical monomeric metaphosphate $ROPO_2$, which reacts vigorously with alcohols to give phosphates and with phosphate anions to yield pyrophosphates:

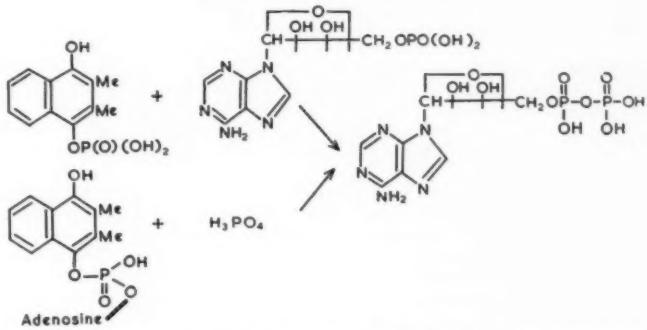


In the case illustrated—the phosphoramidate method—the 'activation' of the reagent is brought about by protonation. But the same effect could be produced by withdrawal of an electron; this is, in fact, the principle of phosphorylation procedures based on oxidation. One in which we have been particularly interested involves quinol phosphates as reagents. Quinol phosphates in presence of oxidizing agents such as bromine, ceric sulphate, or quinones, transfer their phosphate, yielding, at the same time, the corresponding quinone. Thus:

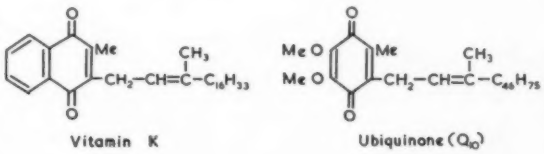


You will notice that we formulate this reaction as producing monomeric metaphosphate. This is supported by a considerable body of evidence. In the first place, the phosphorylation which occurs is a result of the oxidation and is not due to hydrolysis. Quinol phosphates are very resistant to hydrolysis and do not break down in absence of oxygen. Again, although quinol phosphates and their monoesters both undergo this reaction readily with concomitant phosphorylation, quinol phosphate diesters (which cannot yield metaphosphate without hydrolysis) do not, even in presence of reagents as powerful as ceric sulphate. Finally, if quinol phosphates are oxidized in aqueous solution in presence of phosphate anions, phosphorylation occurs to produce pyrophosphate, whereas if oxidized in dimethylformamide in the absence of phosphate considerable amounts of trimeric metaphosphate and only a little pyrophosphate are produced.

These results are of great interest in connexion with the biological problem of oxidative phosphorylation in the respiratory chain, particularly since, in the laboratory, we have been able to show that, for example, adenosine diphosphate can be synthesized either from a quinol phosphate and adenylic acid, or from a quinol ester of adenylic acid and phosphate anion by bromine oxidation.



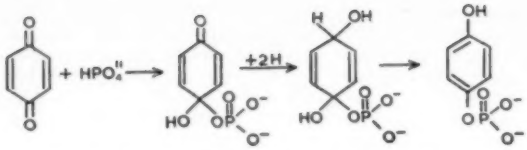

It is difficult to believe that there is no connexion between these observations and the occurrence of vitamin K derivatives and the ubiquinones or coenzymes *Q* in systems where oxidative phosphorylation occurs and the participation of which is strongly suggested by available biochemical evidence.



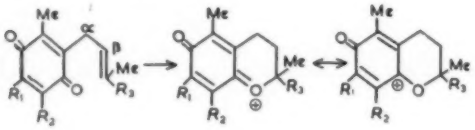

We suggest that these substances are involved in oxidative phosphorylation as the phosphates of their reduced (that is, hydroquinone) forms.

Although this suggestion readily explains the production of adenosine triphosphate through intervention of these natural quinones as their reduced phosphates, there still remains the problem of how these phosphates are produced from the quinones and phosphate anion so that the whole system can work continuously. It is unlikely that reduction of the quinone to the quinol occurs followed by phosphorylation; this could scarcely be done with phosphate anion, and introduction of a 'high energy' phosphorylating entity to bring it about would seem to make the whole process slightly absurd from a biological point of view.

One theoretically possible method would be a simple reductive phosphorylation of the type shown below; but it must be confessed that, despite many attempts, we have as yet been unable to demonstrate any such reaction in benzoquinones or naphthoquinones under many different conditions.



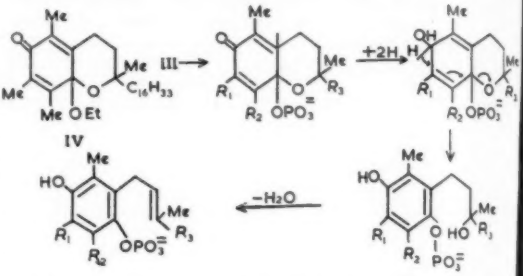
There is, however, another possibility which should be mentioned and which is, indeed, under investigation by Dr. V. M. Clark in Cambridge now. If one examines the structure of vitamin K and the ubiquinones, it is noteworthy that each quinone ring is tetrasubstituted and that each has a trisubstituted double bond in the position $\beta:\gamma$ to the quinone ring. If $H^+$ were added to the $\beta$-position, a tertiary carbonium ion would be produced which should react with the oxygen of the adjacent carbonyl group to produce the cation III.



III

Evidence for the transient existence of anions of this type already exists in the related vitamin E group, where the substance (IV) has been isolated from oxidation of $\alpha$-tocopherol with ferric chloride in ethanol. Attack on (III) by phosphate, followed by reduction, should yield the desired quinol phosphate.

If such a scheme can be realized in the laboratory, then it would provide a completely rational picture of the participation of these complex natural quinones in biological oxidative phosphorylation.



I have tried to exemplify, by talking about these aspects of the chemistry of organic phosphates, some of the ways in which advancing organic chemistry is helping at once to clarify certain biological problems and to open up new vistas of potential progress. But I should not like it to be thought that these are the only examples I could have chosen, nor that it is only through the field of biological studies that new vistas are to be found. This is far from true, as could be shown by considering, for example, some of the brilliant recent studies in hydrocarbon transformation and polymerization. But my own research interests have lain largely on the biological side of organic chemistry and I hope, therefore, that I shall be forgiven if I have chosen my illustrations from it.

# GEOMAGNETIC STORMS AND THE SPACE AROUND THE EARTH*

By Prof. SYDNEY CHAPMAN, F.R.S.
High Altitude Observatory, Boulder, Colorado

'MAGNETIC storm' is the name long ago given to magnetic disturbance or irregular activity in its more extreme forms. The study of geomagnetic disturbance began in the eighteenth century, with Graham's observations of the compass needle. These were made by eye with a microscope. Eye observation was later improved by use of a moving spot of light on a scale, reflected from a lamp by a mirror attached to a needle. This method made serious demands on the time of the observers, and gave very incomplete information. Yet it was used as late as the first International Polar Year, 1882–83, although in 1846 Airy had introduced photographic observing at Greenwich Observatory. Through the inventions of Gauss, and his influence and that of Humboldt, magnetic observatories for the observation of all three magnetic elements were instituted in increasing numbers from about 1840 onwards. Sabine notably advanced our knowledge of magnetic disturbance by his studies based on the records of the British Colonial Observatories at St. Helena, Toronto and Hobarton. His contribution was largely to the 'morphology' of magnetic disturbance—concerning the distribution and changes of the disturbing magnetic field over the surface of the Earth. Later principal studies in this field were made by Moos in 1910, by Chapman in 1918, and from 1952 onwards by Sugiura and Chapman.

Sabine, Lamont and others contributed also to our knowledge of the time distribution of the occurrence of magnetic disturbance. Soon after Schwabe in 1851 recognized the sunspot cycle, they showed that it is manifested also by magnetic activity. Later, the tendency to a 27-day recurrence was discovered and investigated in different ways, especially by Broun, Maunder, Chree, Stagg and Bartels. It was interpreted as indicating the emission of corpuscular streams from particular areas on the rotating Sun. These streams produce magnetic storms (or less activity) when they impinge on the Earth. Greaves and Newton showed that the greatest storms do not show this tendency towards a 27-day recurrence. They are found to be often associable with solar flares. These are believed to involve the ejection of limited clouds of gas. The time-interval between flares and their associated magnetic storms indicates a speed of travel of the cloud of about 1,000 km./sec. There is some indication that the gas in the continuing streams may travel rather more slowly.

How solar streams and clouds are ejected is still unknown. Scant visual evidence that they are

* Substance of three University of London Special Lectures delivered at Queen Mary College during June 1–3.

ejected comes from photographs of the edge of the Sun. Solar radio later indicated the rise of gas in the Sun's atmosphere, with speeds that would lead to escape. The streams may be generally invisible because of practically complete ionization of their main constituents, atomic hydrogen and helium. But the hypothesis of causation of magnetic storms by corpuscular flux from the Sun was a reasonable inference without such evidence. Even now the solar sources of corpuscular 'streams' have not been certainly identified.

Birkeland attempted a physical theory of magnetic storms and the associated phenomenon of the aurora polaris. He ascribed them to streams of solar electrons. From model experiments he inferred that the geomagnetic field would deflect them polewards, and that this might account for the existence of the auroral zones and other auroral features. Størmer developed Birkeland's ideas mathematically. He considered almost exclusively the motions of single charged particles influenced only by the geomagnetic field. Schuster and others directed attention to the importance of electrostatic forces between the particles in a stream of charges all of the same sign, such as Birkeland and Størmer contemplated. They urged that such streams could not reach the Earth in sufficient density, because the mutual repulsion of the particles would disperse them widely during their travel.

Størmer did consider the combined action of his particles in one respect, namely, as regards the geomagnetic field caused by the electric current associated with their motion partially surrounding the Earth. He connected this field with the reduction of the Earth's horizontal force during geomagnetic storms. This reduction is one of the most notable features of such storms. Though the suggested electric current was not a complete ring, it came to be linked with the name 'ring current'. The existence of a ring current was postulated by Schmidt on purely geomagnetic evidence, without any proposal as to the location or origin or detailed nature of the ring. Størmer's ring current was not a ring. It was situated far from the Earth (at a distance comparable with that of the Moon). It would greatly alter the field in a manner inconsistent with its own presence there. Further, it could not have the supposed current intensity and yet be composed of charges of one sign only.

Over a period of decades, Størmer studied the paths of single particles in a dipole magnetic field. The intended explanation of auroral phenomena had little success, but his work proved highly valuable in connexion with cosmic rays—a phenomenon unknown when his work began.

Lindemann (later Lord Cherwell) added an important constructive suggestion to a justified destructive criticism of a one-sign stream theory proposed by Chapman in 1918 to explain magnetic storms. The suggestion was that the cause of magnetic storms and auroras is a stream or cloud of neutral but ionized gas. Chapman and Ferraro from 1929 onwards tried with some success to develop an inductive theory of the events that would follow the impact of such gas upon the Earth. In this speculative subject there is natural scope for a variety of views as to the significance of their results. To Hulburt a few years ago they seemed to be "of merely historical interest", whereas according to some other authors the Chapman–Ferraro work has "dominated the discussion" of magnetic storm theory for some decades.

The chief conclusions reached were that the geomagnetic field would 'carve a hollow' in the stream; and that electric currents would flow over the surface of this hollow, mainly on the sunward side of the Earth. These currents shield the volume of the stream from the Earth's magnetic field. Also in the parts of the hollow space nearer the equatorial plane they enhance the Earth's field. This is a notable feature observed at and near the commencement of magnetic storms. Such a current continues as long as the flux, and will vary in intensity with the density and speed of the stream particles. It is conveyed by the different motions of the opposite charges, protons and electrons, near the surface of the hollow. The charges are deflected when they enter the very non-uniform magnetic field in the boundary region bordering on the hollow. The particles are turned back less or more directly, according as their approach is farther from or nearer to the line from the Sun to the centre of the Earth.

Simple approximate relations were found between the first-phase increase of horizontal magnetic force in a storm, the density of kinetic energy of the stream, and its distance of closest approach to the Earth. It became clear that the electromagnetic phenomena that produce magnetic storms and auroras take place within a few Earth radii—of order 3 to 10—from the Earth's centre. This scale is much less than that envisaged in Størmer's theory, or in cosmic rays, which are guided by the Earth's field through a much greater region surrounding the Earth. In a later idealized treatment of a problem on the initial approach of a solar stream, Chapman and Ferraro estimated the limits of density and momentum that determine whether the Størmer simple theory is applicable. They showed that for a stream that can exert any appreciable magnetic effect the mutual influence of opposite charges is important.

They tried also to infer the further, main, development of a magnetic storm, but were unable to overcome the mathematical difficulties involved. They made only a tentative suggestion as to how a ring current could begin to grow. The value of this suggestion is still uncertain. Assuming that in some way a ring current is formed, they studied its stability. They conceived the current as toroidal in form : and the particles, positive and negative, as moving with slightly different speeds around the geomagnetic axis, in planes parallel to the geomagnetic equatorial plane.

In 1957 Singer described a different conception of the motion and distribution of the energetic particles in the space around the Earth—in a region of the scale above mentioned. He pictured the particles as moving around and along the Earth's dipole lines of force, to and fro between mirror points in high latitudes, where they attain their lowest levels. This motion would be combined with a slower drift around the Earth. This drift is eastward for electrons, westward for protons. It seemed obvious that this would supply the inferred westward ring current. This was later proved by Dessler and Parker and by Akasofu, but the cause of the electric current proved to be less obvious than at first appeared.

Singer's conception, and the Chapman–Ferraro scale of the phenomena, were confirmed by the discovery and investigation of the Van Allen belts that surround the Earth. The inner, minor, belt seems to be due to the decay of upward-flying neutrons

generated in the Earth's atmosphere by cosmic rays. The outer, major, belt is generally but not universally believed to be fed by the solar streams and clouds. The process by which they are trapped by the Earth's magnetic field is still not clear. The outer belt has been found to vary considerably during the year or two in which it has been studied. U.S.S.R. and U.S. cosmic rockets have confirmed irregularities in the magnetic field in the region of the outer belt, which demonstrate the presence of a ring current.

The particles of the belts are very energetic—of order 100 MeV. for the protons and 600 keV. for the electrons. The density of these protons is extremely low—of order $10^{-6}$ to $10^{-5}$ per cm.$^3$. The electrons are more numerous. The protons and electrons are gradually lost, the protons mainly by charge exchange at the lower levels they reach, especially near the mirror points. Thus the continuance of the belts requires continual replacement by new energetic particles.

Although corpuscular theories of magnetic storms and auroras found wide acceptance, they were not without critics and rivals. One of the latter tried to explain the geophysical phenomena by specially intense ultra-violet emissions from the Sun. Inadequacies and counter arguments prevented these theories from making much headway. Corpuscular theories, on the contrary, gained important direct support in 1950 from a spectrum obtained by Meinel of an aurora nearly overhead. It showed lines of atomic hydrogen much displaced towards the ultra-violet. This was interpreted as a Doppler effect indicating the downflow of hydrogen atoms with a speed of order 3,000 km./sec. It was naturally inferred that the atoms reached auroral latitudes as protons—guided by the geomagnetic field—and there gained an electron during their descent through our atmosphere. The speed, 3,000 km./sec., was thrice that deduced from travel-time delays between great flares and their succeeding magnetic storms. The discrepancy had already been noted in another connexion. This was the speed necessary for particles coming from outside, if they were to penetrate to the observed lower levels of auroral luminosity.

Further evidence has since been obtained that both protons and electrons do penetrate to these and indeed to much lower levels. This was first shown in the years 1952–53 by the rockoon studies made by Van Allen and his colleagues in latitudes up to more than 80°. The rockoons, fired in the day-time, carried cosmic ray recorders up to heights of 80 km. or more. In latitudes from about 62° to 75°, they showed that, besides cosmic rays, other less energetic agents added to the record. These agents were later interpreted as X-rays, of average energy about 30 keV. (but running up to 100 keV.). These X-rays were explained as Bremsstrahlungen generated by a small minority of electrons (about 0·1 per cent) in close impact with the nuclei of atmospheric atoms and molecules. The great majority of these electrons were stopped at higher, auroral levels of order 100 km. The flux of electrons appeared to be continual, not confined to great auroral occasions. The rockoon launchings, made in years of moderate solar activity, did not coincide with such occasions.

More recently rocket and balloon studies at night, during notable auroras, have disclosed the entry at such times of protons as well as X-rays generated by electrons. They have been detected down to levels as low as 30 km. during strong overhead auroras, by Winckler and his colleagues. This suggests that at such times electrons and protons enter the atmosphere in special abundance, and with speeds much greater than those inferred by Meinel.

The strongest features of magnetic storms as observed at the Earth's surface are recorded in and near the latitudes where the auroras then occur. These latitudes are below those, 65°–68°, of the 'auroral zone', the zone of most frequent auroral visibility. The magnetic records indicate the presence of strong electric currents along these abnormal auroral latitudes. The intense current is limited laterally, and is therefore called an electrojet. The current circuit is completed mainly in higher latitudes over the polar cap, but also over the great middle belt of the Earth between the northern and southern auroral latitudes. These currents flow in our atmosphere: they are more often westward than eastward, corresponding to 'negative' rather than 'positive' polar magnetic 'bays'. The former occur during late evening to early post-dawn hours, the latter during the afternoon and early post-sunset hours. They and the part of the storm field associated with them seem to develop in impulsive bursts, with quieter intervals between. They are closely associated with striking phases of the aurora during magnetic storms.

The morphology of the aurora is complex. The great increase in visual and instrumental auroral observation during the International Geophysical Year is adding, and will add further, greatly to our knowledge of the extent and changes of the aurora in association with magnetic, solar and other phenomena. At present there is a diversity of theories of the auroral luminosity and the electric currents linked with it. Almost all involve the now proved entry of electrons and protons into our ionosphere from beyond. They come ultimately from the Sun, but some theorists consider that before descent to auroral levels they may spend some time as denizens of the Van Allen belts. Some theories envisage the participation of solar magnetic fields transported from the Sun by the solar streams and clouds. Such fields could hold, among the particles travelling more directly, others of much higher energy and speed, spiralling around the magnetic field lines in the stream or cloud. Hoyle and Dungey attributed importance to two neutral points in the combined geomagnetic and transported solar fields. They suggested that such points may be a means whereby solar particles may enter the atmosphere with added energy and penetration. Other theorists attach importance to atmospheric winds in connexion with auroral luminosity and movements, and with the generation—by dynamo action—of the polar magnetic disturbance currents. Martyn associated the acceleration of particles entering the atmosphere with electrostatic potential differences across the section of a ring current of the type envisaged by Chapman and Ferraro. He also explained the impulsion of the polar disturbance currents by these potential differences, supposed transferred along the lines of force to auroral levels.

A new theory of auroral morphology and of the magnetic disturbance currents, by Akasofu and Chapman, is now nearing partial completion. One novel feature of the theory is the attribution of importance to neutral *lines* in the magnetic field around the Earth. These lines, mainly lying on the night side of the Earth, are associated specially with

the combination of the ring current and corpuscular flux fields with the Earth's main field. Subsidiary hypotheses are involved, without present proof, to explain several complicated features of the phenomena observed.

Until recently most auroral and storm theories based on solar streams and clouds ignored the possible permanent presence of gas in interplanetary space and in the region around the Earth where the ring current and corpuscular flux current are believed to flow. The magnetic changes associated with these currents were supposed to be transmitted to the Earth's surface as if *in vacuo*. The radio phenomena of whistlers, elucidated by Eckersley and Storey, indicated the presence of electrons in at least part of the region. Parker for a time concluded that this would almost prevent the fields of the ring current and corpuscular flux current from affecting the Earth's surface field. Controversy with Hines finally led to agreement that this bar to transmission was misconceived. But the transmission will be by hydromagnetic waves rather than purely by electromagnetic waves. Chapman in recent years has inferred that the Sun's coronal atmosphere extends up to and beyond the Earth, and that this interplanetary gas is very hot even up to the Earth's distance. He has further concluded that, if so, the Earth's atmosphere could be enormously more extensive than formerly supposed. This would imply that the Van Allen belts lie relatively low in our atmosphere. But the atmospheric gas in their region, though far more dense than the energetic gas of the belts themselves, would probably be too rare to have much influence on the development of magnetic storms and auroras.

# OBITUARIES

## Prof. Charles Singer

Dr. Charles Singer, the eminent historian of medicine, science and technology, died at his beautiful home, 'Kilmarth', near Par, Cornwall, on June 10, in his eighty-fourth year.

A son of the distinguished Hebrew scholar, the Rev. Simeon Singer, minister of the West End Synagogue, Charles Singer was born in Camberwell, on November 2, 1876, and was educated at the City of London School. At the age of seventeen he became a medical student at University College, London. But the delights of biology were at first too strong, and after a year he turned to the study of zoology and botany under Weldon and F. W. Oliver, respectively. After two years of these studies, he was by a chance invited to enter for a scholarship at Magdalen College, Oxford. His success resulted in his spending three years at that College, studying zoology under Weldon (now transferred to Oxford) and under E. S. Goodrich, for both of whom he retained an immense admiration. In 1899 he graduated B.A. at Oxford, and then returned to London to continue his medical studies at St. Mary's Hospital, Paddington.

Singer qualified M.R.C.S., L.R.C.P. in 1903, and at once departed to Abyssinia as the medical officer to a survey expedition to that country. The result was his first paper (1904) on some unusual clinical conditions. Back in Britain, he filled various resident posts to fit himself for a clinical career, and graduated B.M., B.Ch. at Oxford in 1905. He then had an extensive period in a post in the Government Hospital at Singapore. After his return to England, he became physician to the Dreadnought Hospital and concurrently registrar to the Cancer Hospital in Fulham Road. In the latter post he did much clinical research and laboratory research alone and in collaboration with S. B. Schryver. In 1913 he described a nematode worm in a gastric carcinoma in a rat. He discovered it in the same week in which Fibiger published the researches for which he received a Nobel Prize.

Charles Singer had entered the field of the history of medicine in 1911. He took a prominent part in the early proceedings of the History Section of the Royal Society of Medicine, established in 1912. Osler was its first president, and just before the outbreak of the First World War he offered Singer a post at Oxford, the duties of which were to be mainly historical. Singer's tenure of this post was interrupted by the War, during which he served, mainly at Malta and Salonika, with the rank of captain in the R.A.M.C. But before he was commissioned early in the War he had time to establish, with the help of his wife, Dorothea Waley Singer, whom he had married in 1910, a History of Science Room in the Radcliffe Camera, which is still remembered.

After the War, Singer was invited in 1920 to lecture on the history of medicine at University College, London, and for a short time he continued to hold both the London and the Oxford posts. With his resignation from Oxford there began the most prolific period of his life. In 1930 the University of London conferred on him the title of professor, and he became professor emeritus on his retirement in 1942. In 1930 and again in 1932 he acted as visiting professor at the University of California, Berkeley, where he lectured to enthusiastic audiences. In 1934 he removed his residence to the house near Par, in Cornwall, which was to be his home during the remainder of his long life. Many friends from all over the world remember with pleasure and regret the hospitality so generously extended to them at 'Kilmarth'.

Until he was more than fifty, Singer's interests lay mainly in the history of medicine. In that field he published in rapid sequence several works which opened new ground and led to further study by others. His "Early English Magic and Medicine" (1920) was probably the first serious study of Anglo-Saxon medicine since Cockayne. To the history of anatomy he contributed two important books on medieval anatomical texts (1924–25), and in the latter year there appeared his "Evolution of Anatomy", the substance of his FitzPatrick Lectures. This work was virtually the only history of anatomy in English. The close of this book with Harvey indicated the limit of Singer's serious interest in the history of medicine. Apart from ephemeral writings, none of his original work on the history of medicine dealt with events after the Restoration. He was deeply interested in Greek and Roman medicine, in the medicine of the Dark Ages, and in the history of syphilis. His important paper on the herbal in

antiquity was published in 1927. His early medical period closed in 1928 with the publication of his "Short History of Medicine".

Singer's interest in the history of science was at first confined largely to biology and the history of microscopy. The first volume of his "Studies in the History and Method of Science" (1917) contained papers by him which were medical rather than scientific; but the second volume (1921) contained his very important study of Greek biology, and also his paper on the invention of the first optical apparatus. Thereafter he published (1922) his useful little book on "Greek Biology and Greek Medicine". After that, occasional papers on biological and scientific subjects began to appear, and in 1931 he published—as a result of his American lectures—his "Short History of Biology", one of his best books, which he afterwards revised twice.

After this, it was ten years before Singer published another important book. In the intervening period he had spent nearly a year in the United States, had removed to Cornwall, and had written many articles and reviews. He had also played a prominent part in the foundation of the Society for the Protection of Science and Learning, for he was deeply saddened by what happened to European scholars before the outbreak of the Second World War. He had also been reading widely in the literature of science, and the result was his "Short History of Science", published in 1941. This work was much read because it covered the whole field to 1900 within reasonable compass; it introduced a new approach and was easily understood. Towards the end of the War he worked on the "Tabulae anatomicae sex" of Vesalius, and later he completed the philological aspects in collaboration with Prof. Chaim Rabin. This work was published in 1946 as "A Prelude to Modern Science".

In the closing years of the War, Singer was asked by Mr. Derek Spence to write the history of the alum trade; Mr. Spence's well-known firm, dating back to 1855, contributed much to the later history of that trade. For Singer this was a new departure, and he devoted several years of enthusiastic work to this effort. The result was the fine folio volume, "The Earliest Chemical Industry", published in 1948.

Singer next turned to three medical projects which had long been in his mind. The first was the completion, in collaboration with his old friend, Prof. J. H. G. Gratton, of a definitive text of the Anglo-Saxon work known as the "Lacnunga". This work was published in 1952, as also was the second of these projects, a translation of the seventh book of the "Fabrica" of Vesalius.

The need for an authoritative work on the history of technology had long been understood by Singer, and after the publication of his work on the alum trade he devoted much time to the planning of a co-operative work on this subject. The drawing up of these detailed plans for five large volumes must be considered as one of Singer's finest pieces of work. It gave him scope for the use and display of his vast knowledge of men and books, and for the extensive correspondence in which he delighted. Although he had associated editors, chief of whom was the late Dr. E. J. Holmyard, Singer played the main part in the planning and editing of this work. The first volume was published in 1954, and the fourth and fifth volumes in 1958. During its publication he completed and published his last original medical work, his annotated translation of "Galen on Anatomical Procedures" (1956).

In 1922 Singer was awarded a D.Litt. at Oxford for his thesis on the manuscripts dealing with St. Hildegard of Bingen. He already had the Oxford D.M. (1911), and in 1936 that University conferred on him the honorary degree of D.Sc. He became a Fellow of the Royal College of Physicians in 1917. Later in life he became a Fellow of University College, London, an Honorary Fellow of the Royal Society of Medicine, and an Honorary Fellow of his old college, Magdalen, at Oxford. He delivered the L. T. Hobhouse Memorial Trust Lecture in 1951, and the Lloyd Roberts Lecture in 1954. He was president of the History of Medicine Section of the Royal Society of Medicine during 1920–22, and first president of the British Society for the History of Science (1946–48). He was also president of two International Congresses held in London (History of Medicine, 1922; and History of Science, 1931). In 1947 he was president of the International Union for the History of Science. He was awarded the Osler Medal and the George Sarton Medal. In 1953 Singer was the recipient of a large work containing historical essays written in his honour ("Science Medicine and History", 2 vols.; London, 1953).

Singer was by inclination and training a biologist, and to the end of his life he rather regretted that he had not taken up this subject as a profession. When the King's School at Canterbury was evacuated to the west of England early in the Second World War, he was induced to take over the teaching of practical biology. For this purpose he had a room in his house fitted out as a laboratory, and during most of the War he taught in it pupils attending that and another school. It gave him great satisfaction that he consistently obtained a very high standard of passes. In botany, Singer was especially interested in the succulents, and in front of his desk there stood a thriving array of these plants.

Charles Singer will be remembered as much for the encouragement which he gave to others as for his own numerous and important contributions to his subjects. His large correspondence testified to the advice which he gave. But his inspiration and encouragement flowed most easily in his conversation. Those who knew him well appreciated that, despite his learning, his humanity was perhaps the outstanding feature of his character. He had a rich fund of humour, and he could talk simply to the unlearned about subjects which were by no means simple. His studies in the local history and customs of Cornwall were unpublished, and were probably known to very few except his Cornish neighbours.

E. Ashworth Underwood

## Dr. Geoffrey Builder

The sudden death of Geoffrey Builder at the early age of fifty-four has deprived the University of Sydney of an original and sympathetic teacher of physics and Australia of a scientist of international reputation. Born in Western Australia, he was educated at Guildford Grammar School, the Perth Technical College and the University of Western Australia. After graduating in 1928 he joined the Watheroo Magnetic Observatory of the Carnegie Institution of Washington and was responsible for developing a radio technique for the rapid transmission of geophysical data to Washington.

In 1931 Builder commenced work under me at King's College, London, on the exploration of the

ionosphere, in which researches he was largely responsible for the discovery of the magneto-ionic splitting of pulse radio echoes and the quantitative verification of ionospheric double refraction which had been predicted by a theory of mine. During July 1932–May 1933 he was a member of the British Radio Expedition to Tromsø, in North Norway, organized by the Royal Society as part of Britain's contribution to the work of the Second International Polar Year. It was this expedition which discovered the phenomenon of the polar radio 'black-out', associated with magnetic storm and auroral activity.

After obtaining the London degree of Ph.D., and becoming a Fellow of the Institute of Physics, Builder joined the Australian Radio Research Board in the latter part of 1933. He then played an important part in developing the Board's new experimental techniques for ionospheric exploration and collaborated with the late A. L. Green in researches on the polarization of long radio waves and on the suppression of fading.

Towards the end of 1934 he joined Amalgamated Wireless (Australasia), Ltd., to take charge of its small group of research laboratories. Under his energetic and skilful direction this group developed rapidly until, at the time of his departure for the Army in 1941, it had grown into an effective organization with more than fifty members of staff. Many well-known Australian radio-physicists and engineers owe their selection and early professional training to the shrewd judgment and scientific and administrative capacity which he exercised during this period as chief of research.

While a major at Army Headquarters during part of the Second World War, Builder acted as adviser on radar, and later engaged in defence production as general manager of Airzone, Ltd. After the War he worked as a consultant and founded two electrical engineering companies. During part of this time he was able to give valuable assistance to the Department of Physics of the University of Sydney in coping with its excessive load of teaching. In 1949 he was appointed to the permanent staff of the Department as a senior lecturer and devoted himself largely to giving lectures on electricity and to the duties of the lecturer-in-charge of second-year physics.

As a member of the Faculty of Science he was very active in proposing various reforms and successful in getting many of them adopted. In recent years he developed an interest in the theory of relativity and gave much time and thought to resolving the famous clock paradox of the special theory. These researches were carried out with his usual thoroughness and acumen and, although at times they brought him into conflict with well-known theoreticians, one of his last papers[1] appears to have settled the controversy by showing that "the clock paradox . . . arose solely out of the elementary mistake of utilizing, in a single calculation, quantities expressed in the measures of two different reference systems". Such versatility and depth are not often found among the younger generation of physicists.

Builder's great interest in the welfare of his students, both collectively and individually, and his exceptional combination of technical, commercial and academic experience made him one of the most successful of teachers and a constant source of wise counsel to his academic colleagues.

EDWARD V. APPLETON

[1] *Amer. J. Phys.*, **27**, 656 (1959).

## Georges Claude

AVEC Georges Claude (décédé le 23 Mai) vient de disparaître un des derniers pionniers, inventeurs, ingénieurs, savants, qui ont permis la révolution industrielle qui précéda la Première Guerre Mondiale. Ingénieur débutant, Georges Claude s'intéresse à l'acétylène, rendu accessible par la fabrication au four électrique du carbure de calcium ; en 1896, il crée l'industrie de l'acétylène dissous et permet l'essor de la soudure autogène, du découpage au chalumeau : les techniques de la construction mécanique sont immédiatement transformées.

Claude se préoccupe alors du prix de revient de l'oxygène, non pas tant pour abaisser le prix de la soudure au chalumeau que pour son application à la production des hautes températures. Avant la fin du siècle dernier, il envisage la possibilité de fabriquer le carbure de calcium dans un four à charbon soufflé à l'oxygène ! Ses efforts sont couronnés de succès et la détente avec travail extérieur, qu'il industrialise dès 1902, est universellement utilisée. En 1910, il démontre dans les aciéries belges d'Ougrée la possibilité d'économies substantielles en sidérurgie par l'emploi de l'oxygène. Depuis la fin de la Deuxième Guerre Mondiale, ses prévisions ont été très largement justifiées ; l'avenir montrera, nous en sommes convaincus, que la production du carbure de calcium au four soufflé à l'oxygène n'était pas davantage une utopie.

Claude s'intéresse également aux gaz rares de l'air et réalise la production industrielle de l'argon, du néon, du krypton et du xénon. L'éclairage à incandescence s'en trouve transformé et ces travaux ont conduit à l'éclairage par fluorescence dont nous jouissons maintenant.

Au cours de la Première Guerre Mondiale, Georges Claude s'attaque à la synthèse de l'ammoniaque ; aux 250 atmosphères du Prof. F. Haber, il oppose audacieusement les 1,000 atmosphères auxquelles il prétend travailler, et il y réussit. Son procédé est encore employé et l'on peut dire que les procédés Casale ou Fauser ne sont qu'un compromis raisonnable entre les pressions déjà courantes du temps de Haber et les hyperpressions dont Claude a rendu possible l'emploi.

Du domaine des hyperpressions, son imagination créatrice entraine Georges Claude vers l'emploi des pressions réduites. Passionné des grands problèmes qui dominent l'avenir du monde, il voit là un moyen d'utiliser l'inépuisable réservoir d'énergie que constituent les océans par la différence de température entre les couches superficielles et les couches profondes de l'eau. Dans une première installation, il réussit à entraîner une dynamo de 60 kW. par une turbine mue par de la vapeur à faible pression qui se condense au contact d'eau froide. La différence de température n'est que de 20° C. ; l'eau de la Meuse lui sert de source froide, et il prend comme source chaude cette même eau servant à refroidir les tuyères du haut-fourneau.

Georges Claude s'engage alors tout seul dans l'expérimentation industrielle. A Cuba, après trois tentatives, il immerge dans le fond de l'océan un tube de deux mètres de diamètre et de plus de deux mille mètres de long. Il réussit à faire fonctionner son turbogénérateur et peut éclairer la station expérimentale qu'il a construite de ses deniers. Une nouvelle tentative pour atteindre une échelle industrielle (2,000 kW.) échoue par suite de l'hostilité des éléments, déchaînés contre un inventeur génial. La

fortune considérable gagnée par Georges Claude ne lui a pas permis de mener à bien, tout seul, l'audacieuse expérience de captation de l'énergie thermique des mers.

Le succès de l'opération *Pluto* durant la Deuxième Guerre Mondiale, les projets actuels de pipe-lines traversant la Méditerrannée sont le fruit de la tentative de l'inventeur français. Au moment où s'estompent les espoirs trop optimistes fondés sur la conquête rapide de l'énergie nucléaire à bon marché, on ne peut pas s'empêcher d'une certaine mélancolie en considérant qu'un effort beaucoup moins onéreux aurait pu réussir à nous mettre en possession d'une énergie équivalente et ne présentant pas les mêmes dangers.

Avec le recul des années, l'oeuvre de Georges Claude prend tout son relief : il fut, dans toute l'acception du terme, un véritable créateur dont le génie inventif a généreusement servi son pays et la civilisation oxydentale. J. Cathala

# NEWS and VIEWS

## Mathematics at Oxford : Dr. Graham Higman, F.R.S.

Dr. Graham Higman, who has recently been appointed to the Waynflete chair of pure mathematics in the University of Oxford, in succession to the late Prof. J. H. C. Whitehead, is a Balliol man who, apart from a brief sojourn in Cambridge, has divided his academic life between Oxford and Manchester. After the Second World War, he joined the mathematical staff of the University of Manchester as a founder member of the algebra school which has flourished there since that time. He remained in Manchester until 1955, when he accepted a readership in Oxford. As a pupil of J. H. C. Whitehead, he first worked on a problem of topological origin. In his hands it soon became algebraical, and in the rest of his career he has devoted himself entirely to the 'pure' theory of groups, especially infinite groups. To this theory he has made deep and influential contributions. Lately he has turned his attention to the border country of group-theory and logic, in which he has proved a theorem of great interest on the insolubility of certain group-theoretic problems. Dr. Higman was elected a Fellow of the Royal Society in 1958.

## Seismology in New Zealand : Dr. F. F. Evison

Dr. F. F. Evison has been appointed superintendent of the Seismological Observatory, Wellington, New Zealand (Department of Scientific and Industrial Research), in succession to Mr. R. C. Hayes (*Nature*, **187**, 24 ; 1960). Dr. Evison was educated at West Christchurch High School and the Victoria University of Wellington, graduating in mathematics and physics. In 1947 he went to the Imperial College of Science and Technology, London, as a research student under Prof. J. McG. Bruckshaw, where he developed the technique of experimental seismology in which a transducer is used for generating seismic pulses in the ground. After returning to New Zealand in 1950 to join the Geophysical Survey, he brought this technique to bear on a variety of seismic propagation problems. He also made a study of deformations of strata in coal-mines. In 1956 the Nuffield Foundation awarded Dr. Evison a Dominion Travelling Fellowship in the Natural Sciences, which took him for a year to the Department of Geodesy and Geophysics, Cambridge. Dr. Evison and his colleagues produced the first geophysical evidence that the Antarctic ice-cap is underlain by a continental crust. They have recently extended the work, which depends on dispersive earthquake waves recorded in Antarctica, to obtain crustal thicknesses over the greater part of Antarctica and the surrounding oceans. The Seismological Observatory, Wellington, operates the Antarctic seismograph stations at Scott Base and Hallett, and also stations at Samoa and Raoul Island, as well as the network within New Zealand itself.

## The Russian Earth Satellite 1960λ

A significant milestone on the road to space flight was passed on August 20, when, for the first time, living animals were successfully brought back to earth after being in orbit in space, aboard the second Russian space-ship satellite. This satellite, which weighed 4,600 kgm., was launched at about 08h. 45m. U.T. on August 19, and entered a nearly circular orbit, inclined at an angle of 65·0° to the equator. Its height varied between 306 km. at perigee and 340 km. at apogee, and the period of revolution was 90·7 min. The satellite, also known as *Sputnik* 5, was designated 1960λ1, and was accompanied in orbit by its final-stage rocket (1960λ2). The living creatures in the satellite included two dogs, 40 mice (21 black and 19 white) and 2 rats ; there were 15 phials containing *Drosophila* and 12 with the alga *Chlorella* ; seeds of maize and many other plants, cancerous cells, and a variety of micro-organisms. The satellite also carried a radio transmitter having a frequency of 19·995 Mc./s., and instruments for measuring the composition of cosmic rays and the intensity of solar X-ray and ultra-violet radiation. It is stated that the pulse and rate of respiration of the dogs were measured and their behaviour observed by television, the information being stored and telemetered back to earth. On the eighteenth revolution of the satellite its velocity was reduced by a retro-rocket and it descended through the atmosphere ; all the animals and biological specimens are reported as being recovered in good condition.

## Research and Development in Industry

Dr. E. J. Solvay's presidential address to the Society of Chemical Industry at Bristol on July 5 reviews the evolution of the chemical industry, and more particularly the part which research has played in the development of the industry. He also stressed the need for more men in scientific research and for the more effective use of such highly trained manpower (*Chem. and Indust.*, 976 ; July 30). Urging a real co-ordination of research programmes on an international scale as the result of agreement freely negotiated between companies interested in the same activities, Dr. Solvay was thus endorsing a plea which Viscount Chandos had made earlier in the year to

the British Electrical Power Convention. Lord Chandos, who delivered the Messel Medal address to the Society of Chemical Industry on May 6 (*Chem. and Indust.*, 1037 ; August 13), did not in that address renew this plea ; but, dealing with research and finance in industry, suggested that statements that research and development effort in Britain are too small are misleading. He put expenditure in Great Britain on research and development in 1959 at about £450 million, of which the Government financed one third of that carried out by private industry ; about 27 per cent of the total is in the hands of Government and nationalized industry and performed by them. Lord Chandos believes that more attention should be given to the wider implications of this huge research and development effort. Man's ability to create wealth is increasing much faster than is generally appreciated, and we must be prepared to take some risks to ensure that our means of exchange should increase in a planned and calculated way parallel with the new wealth.

## Arctic Institute of North America

THE Arctic Institute is inviting applications from research scientists interested in arctic and subarctic North America and in Antarctica. The aims of the Institute's grant-in-aid programme, which last year numbered thirty-five awards ranging in value from 400 to 10,000 dollars, are to support the work of experienced field-scientists and to introduce other competent researchers to polar science. The Institute favours no particular scientific disciplines, but appraises proposals on their individual merit. Grants are usually made for a one-year period. Opportunities for field research in arctic Alaska and Canada have widened considerably since the International Geophysical Year. The Institute can now assist research workers in obtaining laboratory facilities and field-stations for many kinds of work. For example, the Office of Naval Research's Arctic Research Laboratory at Point Barrow, Alaska, offers laboratory facilities for work in oceanography, sea-ice, ecology, geology and soil science, and arctic climatology. The Institute is establishing this year two stations on Devon Island, N.W.T., for glaciological, marine biological and meteorological studies. Opportunities exist at stations on the Ellesmere Island Ice Shelf and Ice Island *T*-3 for work in glaciology, sea-ice, oceanography, and marine biology. The Institute maintains one small glacier station and is associated with another on the northern slope of Brooks Range in Alaska. The Arctic Institute also invites proposals for support of field-research in Antarctica. Applications must be submitted a full year in advance of an antarctic field-season. Further information about the programme and application forms can be obtained from the Arctic Institute of North America, 3485 University Street, Montreal 2, P.Q., or 1530 P Street N.W., Washington, D.C. Applications for grants for 1961 should be sent in before November 1, 1960.

## Boris Kidrich Institute of Nuclear Sciences

VOLUME 10 (March 1960) of the *Bulletin* of the Boris Kidrich Institute of Nuclear Sciences at Vinca, near Belgrade, contains twenty-five articles and one laboratory note contributed by members of the physics, physical chemistry, applied mathematics, electronics and radiobiology laboratories of the Institute. Continuing their work on the development of three basic methods—coincidence, $4\pi$ and solid-angle methods—for the absolute measurement of beta activity, V. Uroševič and co-workers describe techniques and methods developed for the primary standardization of gold-198. The results obtained agreed with measurements made at Harwell on four gold foils to within the limits of the estimated error (2–6 per cent). New apparatus described include a thorium fission chamber, a low-pressure expansion cloud-chamber, and a high-resolution binary and decade counting unit. Nine papers deal with radiobiological topics. The brief news report included in Volume 10 records that during 1959 more than sixty scientists from other research centres visited the Institute. Eight delegations, including representatives of the International Atomic Energy Agency, Poland, France, the U.S.S.R., Cambodia, United Arab Republics, and Ethiopia, were received. A joint meeting of Polish and Yugoslav physicists to discuss beta- and gamma-spectroscopy was held at the Institute during September, a symposium on analytical chemistry during October and a symposium on solid state physics and chemistry during December. The construction of an experimental reactor of 6·5 MW. (2 per cent enriched uranium and heavy water), delivered by the U.S.S.R. in accordance with an agreement between Yugoslavia and the U.S.S.R., was completed, and the reactor, which first became critical on October 28, began to operate officially on December 28.

## Geological Research in the Northern Highlands of Scotland

THE past fifteen years have witnessed active development of geological research in the Northern Highlands, with many younger workers added to those of the pre-war period. The new (third) edition of the "Handbook of Regional Geology" on "Scotland : The Northern Highlands", by Dr. J. Phemister, lists more than 150 references additional to those in the original printing of the second edition in 1948 (H.M.S.O. 5*s*. net). The great majority of these concern detailed researches on the structure, metamorphic history and correlation of the Lewisian and Moine metamorphic rocks ; but in view of the active controversies centred on the interpretation of much of this work at the present time, it was not deemed profitable to attempt a complete summary and assessment of it in the present edition. The bulk of the 1948 text is reprinted without modification, additional paragraphs directing attention to more recent publications. By this means the Handbook will serve as a comprehensive and unbiased guide in this field of research until such time as the main controversies are resolved and we can welcome a definitive fourth edition.

## National Museum of Wales

THE Department of Zoology at the National Museum of Wales, Cardiff, has recently arranged an exhibit to illustrate the interchange of animal species between Wales and some of the Commonwealth countries. For centuries the Merchant Navy has played an important part in this, for animals of different types such as insects, small mammals and lizards as well as plants have been transferred to new parts of the world. Accidental or deliberate importation has led to a mingling of once characteristic types for any particular country. Thus, the British winter-moth is spreading in Canada, the North American

grey squirrel flourishes in Wales and other parts of Great Britain, and the British house sparrow is common in New Zealand. The exhibit at Cardiff is grouped around a model of the old Cardiff-registered cargo vessel *Tredegar Hall* and shows a striking series of insects, spiders, molluscs, reptiles and other creatures accidentally landed at the chief seaports of South Wales from overseas.

## Ethionine and Plant Growth Systems

It has already been ascertained that ethionine is an antimetabolite of methionine and that it has growth stimulatory and morphogenetic effects on excised roots of tomato grown in sterile media. R. L. Lowther and W. G. Boll (*Canad. J. Bot.*, **38**, 437; 1960) have now reported on the effects of ethionine on six different plant growth systems, for example, growth of lateral buds on decapitated dwarf beans, the rooting of excised, etiolated bean hypocotyls, expansion of leaf disks, and so on. It was noted that the pretreatment of sections of etiolated pea shoots with manganese lowered or prevented the stimulatory effect of ethionine. A considerable amount of new observations on various growth effects is set out in some detail. According to the nature of the growth system, ethionine stimulates the effect of auxins or 'antiauxins'. Some relationships between the known effects of ethionine and theories of auxin action, and its possible significance as an inhibitor of adaptive enzyme synthesis, are indicated.

## Translations of Soviet Science into English

The Israel Programme for Scientific Translations has been inaugurated to provide English translations of recent and important Russian books in all branches of science. The programme was initiated by the National Science Foundation, Washington, which supports the programme and selects the material to be translated (Soviet Science in English Catalogue, 1960. Pp. 24. Jerusalem: Program for Science Translations, 1960). The first issue of a catalogue of works translated under this programme lists books which will be available some time before December 1960. The books are photo-offset reproductions of originals typed on IBM electric typewriters and are usually bound in cloth boards with dust jackets.

## New Filmstrips

To their series of natural-history filmstrips, Educational Productions, Ltd., of East Ardsley, Wakefield, Yorkshire, has added four more which will be well received by school-teachers. One contains a series of frames describing common plants and animals of the hedgerow and will be specially suitable for junior schools; a second is of the same type but takes its examples from woodlands. The third, "Flowers of the Marsh and Pool", is of more use for botany scholars in secondary schools and includes some of the rarer plants as well as the more common. The fourth strip contains some excellent photographs of British and foreign butterflies and is the forerunner of a similar strip which will deal with moths. Each strip is accompanied by explanatory teaching notes.

## Ramsay Memorial Fellowships

The Ramsay Memorial Fellowships Trustees have made the following awards of new fellowships in chemistry for the year 1960–61: Mr. Alan Bewick, a general fellowship at the University of Durham; a Glasgow Fellowship to Dr. D. G. Watson at the University of Cambridge; a New Zealand Fellowship to Mr. G. A. Rodley at University College, London; Spanish Fellowships to Mr. José García Contreras, Miss María Covadonga Rodríguez Pascual and Mr. Salvador Oliver Moscardó, all at Rothamsted Experimental Station; a United States Fellowship to Mr. Herbert L. Strauss at the University of Oxford. The Trustees have renewed the following fellowships for the same year to: Dr. P. J. T. Tait (General Fellowship) at the University of Aberdeen; Dr. W. G. Paterson (Canadian Fellowship) at the University of Oxford; Dr. T. Anno (Japanese Fellowship) at University College, London; Mr. F. Baltá Calleja (Spanish Fellowship) at the University of Bristol.

## Announcements

Mr. N. Elson has joined Cossor Communications Co., Ltd., as technical director. Educated at Trinity College, Cambridge, Mr. Elson was employed during the Second World War at the Radar Research Development Establishment, Malvern (formerly the Air Defence Experimental Establishment, Christchurch), where he made notable contributions to the development of the wave-guide. Following a period of research on radio wave propagation at the Cavendish Laboratory and in New Zealand, Mr. Elson was engaged on work on guided weapon systems at Ferranti, Ltd., and has been, for the past six years, in charge of the research and development activities of the Racal Engineering and Instrument Companies as chief scientist.

*The Physics of Fluids*, published by the American Institute of Physics, 335 East 45 Street, New York 17, N.Y., hitherto published bimonthly, will be published monthly, starting in 1961 with volume 4. It is hoped by this means to speed up publication of research on the structure, statistical mechanics and general physics of gases, liquids, plasmas, and other fluids.

The Chemical Society, London, has issued "Handbook for Chemical Society Authors" (Special Publication No. 14), 6*s*. to Fellows, 21*s*. to non-Fellows (post paid). Although primarily intended for authors preparing material for publication by the Chemical Society, the 224-page well-bound volume contains sections on nomenclature and symbols which are of general interest.

Messrs. Johnson, Matthey and Co., Ltd., Hatton Garden, London, E.C.1, have issued a publication, "Products of the Rare Earth Group", recording the properties of the pure rare earth metals and their oxides. The firm can supply the metals in ingots, rods, and sometimes wires, in various states of purity at much lower cost than hitherto.

A conference on Nuclear Physics is being arranged by the Institute of Physics and the Physical Society and will be held in the Department of Natural Philosophy, University of Glasgow, during September 14 and 15. Sessions will be devoted to electron and photon interactions with nuclei at energies below meson threshold; strange particle physics; interactions involving pi- and mu-mesons; nuclear forces and interactions between lightest nuclei ($A < 4$); experimental techniques. The Rutherford Lecture will be given by Prof. C. F. Powell during the meeting; he will speak on "Studies of Nuclear Disintegrations at Very High Energies".

# NEW CHEMICAL LABORATORIES IN THE UNIVERSITY OF SYDNEY

By Prof. R. J. W. LE FEVRE, F.R.S.

CHEMISTRY has been studied in the University of Sydney for 108 years. It began in the early 1850's in basement rooms of what is now the Sydney Grammar School, and was transferred to permanent laboratories in the main buildings of the University as soon as these were ready, about 1858. The foundation professor was the Hon. J. Smith, member of the Legislative Council, who went to Sydney from Aberdeen. Under Archibald Liversidge, Smith's successor, chemistry expanded and moved in 1883 to new premises, to which additions were gradually made through the period 1885–1945. Some details of this history appear in *Chemistry and Industry*, 415 (1951), 736 (1953).

The late Mrs. Brightie Phillips presented to the University of Sydney a sum of £100,000 "on the sole condition that it is to be used for the building of a first wing of a new Chemistry School, and in the hope that it will stimulate other donors". Subsequent grants from the Federal and New South Wales State Governments made the planning of a new building a practical proposition. The late Mr. J. J. Cahill, premier of New South Wales, formally commemorated the beginning of construction by unveiling a plaque on October 18, 1956. The project was completed last year, and chemistry is now installed in its fourth location in the University.

Mr. Cahill's successor in the premiership, the Right Hon. R. J. Heffron, visited the new Chemistry School on June 28, 1960, where he addressed a gathering of University Senate and staff members, benefactors, research workers and senior students, the occasion being "a function to mark the opening of the New Chemistry School".

Mr. Heffron traced the history of the present School from its origins in 1851, spoke in terms of appreciation and congratulation of its development, achievements and status, enlarged on the general importance of chemical industry to the State of New South Wales, and outlined the financial responsibilities which his Government has towards universities and education.

Undergraduate classes were not suspended, and the Premier, with other guests, visited the laboratories where students were working to the normal time-table.

The new building is in a contemporary style, contrasting with the older Victorian Gothic buildings of the University, the earliest of which were the work of the mid-nineteenth century architect, Edmund Blacket. Construction was completed toward the end of 1959; but the building has been progressively occupied as portions were finished. Some 146,000 sq. ft. of floor area are provided. The ultimate cost is about £A.1,500,000.

The plan of the building is roughly 'T'-shaped, lying north-west to south-east. The head of the 'T' is a five-storey block 70 ft. by 240 ft., housing all the undergraduate laboratories, service rooms, stores, boiler room, plant room, compressors, liquid-air machine, etc. The wing seen in Fig. 1 behind the main entrance canopy is largely devoted to research laboratories and staff offices. In line with the front door is another wing containing research laboratories, and leading to the foyers of the lecture theatre block. This contains two lecture theatres, each seating 370, and two others, each seating 170. These, in pairs, are placed back to back, with preparation rooms in between. Store-rooms, undergraduates' reading and

Fig. 1. New chemical laboratories in the University of Sydney as seen from the north

writing room, and a 'kitchen' (making possible the serving of refreshments after public lectures, conferences, etc.) are also in this block. The four theatres themselves are windowless, relying on artificial light and mechanical ventilation.

Features of the building are that all external walls are free of pipes and other extrusions. The roofs slope downwards to the centre lines of each block, along which run a series of vertical ducts containing all rainwater, chemical waste and service pipes, together with fume cupboard and ventilation trunking. Services generally provided include gas, electricity (two- and three-phase a.c. and d.c.), hot and cold water, compressed air, and steam. Outlets for most of these are very generously distributed to ensure maximum future flexibility. Because of the height of the site, water pressure is boosted by compressed air to give a constant 20 lb. per sq. in. on the top floor.

Pleasant features of the completed building are two courtyards to the rear. Here seats have been built and enclose small plots in which shade trees are now being planted. The courtyards are paved with precast concrete slabs, and contain the only explicit luxuries in the whole scheme—two ornamental fountains, and a pair of Italian mosaic tile designs around large supporting pillars, immediately outside the lower lecture theatre block.

Tilden spoke of Liversidge's building as "serving for the present needs of the colony, though in all probability large additions will be necessary before long. About 200 students work in the laboratories . . .". The New Chemistry School in 1960 serves the present needs of some 2,500 undergraduates and about 100 staff and research students. These numbers are expected to increase rapidly; Tilden's remark may soon have to be made again.

# PLANT PATHOLOGY IN THE BRITISH COMMONWEALTH

EVERY five years the Commonwealth Mycological Institute organizes a conference on plant diseases which is attended by official delegates from Commonwealth countries, observers from such bodies as the Food and Agriculture Organization, and invited visitors. Similar conferences on insect pests of plants are arranged by the Commonwealth Entomological Institute, the sister institute within the Commonwealth Agricultural Bureaux. This year the two conferences were held in succeeding weeks, and the final day of the Seventh Commonwealth Entomological Conference was devoted to two joint sessions at which agricultural entomologists and plant pathologists discussed topics of common interest. In the morning, developments in the study of plant viruses and their insect vectors with special reference to their bearing on control were considered, and in the afternoon the link between research work and its application in the field of plant protection was reviewed in a series of papers from Canada, the United Kingdom, Kenya and Nigeria.

On the evening of the same day the delegates to the two conferences attended a reception given by the Government at Lancaster House, where they were received and addressed by Lord Hailsham, Minister for Science.

The Sixth Commonwealth Mycological Conference was opened by A. Perera, of Ceylon, chairman of the Executive Council of the Commonwealth Agricultural Bureaux, at the London School of Hygiene and Tropical Medicine, on the morning of July 15, and this was followed by the first plenary session, at which J. C. F. Hopkins, director of the Commonwealth Mycological Institute, reported on the work of the Institute since the previous Conference, a period of expansion marked by the occupation in 1955 of a spacious new building, increase in staff, and an extension of the services offered to plant pathologists and others.

One duty of the delegates is always to review the working of the Institute and to make such recommendations as they may think fit for the next quinquennium. To aid them in this task, and to lay a foundation for their next day's visitation to the Institute at Kew, the papers given during the remainder of the first day dealt largely with different aspects of the Institute's activities.

The primary function of the Institute was to provide an information service, and its main abstract journal, the *Review of Applied Mycology*, which surveys the world literature on plant pathology, is now in its thirty-ninth year. The exact size and extent of the literature of plant pathology are uncertain. The annual output is perhaps 5,000 items derived over the years from 2,000 current publications, but many of these items are popular and ephemeral. The 3,070 abstracts in the 1958 volume of the *Review* came from 530 different journals, 59 books, and 71 reports—a total of 660 publications—and an analysis of a series of volumes since 1925 suggested that while the scatter of papers is broadening more papers are being noticed from a few major journals. Similarly, the language scatter is on the increase, but while the proportion in French is definitely on the decline, that in Japanese, Chinese, and especially Russian is on the increase; the amount in English now stands at 60 per cent, to which another 10 per cent can be added for papers in languages other than English which have English summaries. With regard to types of disease, the number of papers on bacterial diseases is on the increase but their proportion (5 per cent) seems to be slightly less than it was; those on virus diseases have increased from 6 per cent in 1925 to 18 per cent in 1958. Papers on fungal infections have remained remarkably constant for the past thirty years at about 60 per cent of the total, and thus account for the importance of the Institute's identification service and the help it gives in cataloguing fungi from different parts of the world, especially the tropics. During 1958–59, some 4,000 identifications were made and the Institute's herbarium (Herb.I.M.I.) now comprises more than eighty thousand specimens. There are, however, still many taxonomic uncertainties, and M. B. Ellis, the Institute's chief mycologist, emphasized the benefits which accrue from working visits of both experienced and less experienced taxonomists to each others' herbaria. The herbarium is supplemented or com-

plemented by a collection of living cultures which constitutes the main section of the United Kingdom national collection of fungi, and the curator, H. A. Dade, indicated some of the collection's many contacts and uses. The most recent addition to the Institute's resources is a bacteriological laboratory for the study of plant pathogenic bacteria.

Two-thirds of the world's population is undernourished. The losses of crops from disease are immense. According to E. Hainsworth, preventable losses from crop diseases in Kenya account for one-tenth of the entire agricultural output. In other words, he estimated that one quarter of this loss could be economically prevented by spraying or dusting with fungicides, one quarter by the use of disease-resistant plant varieties, and rather more than one half by the use of seed dressings and the preplanting treatment of seeds. For other diseases no control measures may be available, or the increase in costs from applying an efficacious control would not be commensurate with the increased monetary value of the crop. For example, as J. W. Blencowe and A. L. Wharton of the West African Cocoa Research Institute indicated, though the absolute loss of crop of cacao caused by black pod disease (*Phytophthora palmivora*) in southern Ghana and Ashanti is of the order of 23 and 16 per cent, respectively, and must represent a cash loss of several million pounds, the application of fungicidal sprays is not at present economically justified. The economics of control are, however, under experimental study.

Such data offered to the Conference give clues to modern trends in plant pathology. Up to the First World War may be considered to have been the age of the pathogen. Plant pathology was undertaken by mycologists. Emphasis then shifted to the diseased plant both in relation to the pathogen and the totality of the environment, physical, social, and economic. Plant pathology became a profession. In human medicine, increasing attention is being paid to public health, to the prevention rather than to the cure of disease, and it now seems that this attitude is also gaining ground among plant pathologists. It may be recalled that just over a century ago the Rev. Miles Joseph Berkeley, one of the founders of plant pathology, began his famous series of articles on vegetable pathology in the *Gardeners' Chronicle* with an account of the plant in a state of health. The wheel is turning full circle.

During three days of the reading of papers, some thirty contributions were made by nearly forty different authors on half a dozen main topics, all of current interest.

Throughout the world, and in diverse crops, root rots are being intensively studied. Losses in annual crops can be serious, but the problem of root rots in plantation crops and in forest trees is in many countries particularly acute. I. A. S. Gibson and N. A. Goodchild dealt with *Armillaria mellea* root rot of tea in Kenya, a paper by A. Riggenbach covered white root disease (caused by *Fomes lignosus*) and its control in *Hevea* rubber in Ceylon and R. A. Fox reported on the same disease in Malaya. These tropical examples were followed by a review by J. S. Murray (Forestry Commission) of the increasingly serious depredations caused by *Fomes annosus* among conifers in the United Kingdom. Two further papers, by D. A. Perry (Empire Cotton Growing Corporation) on a *Fusarium* wilt of cotton in Uganda and by C. D. Blake on a banana root rot in New South Wales, provided interesting examples of root rot complexes in the etiology of which nematodes play an important part; successful control of the banana disease being by disinfesting planting material by hot-water treatment and planting in virgin areas or areas which have not carried bananas for at least five years. Such results, and the recognition of nematodes as vectors of some plant viruses, led to resolutions being adopted at the final plenary session for increased emphasis not only on investigations of root rots but also on studies of nematodes, and the desirability of including an introduction to nematology in the training of plant pathologists.

Seed pathology and seed-health testing were comprehensively reviewed at another session by Mary Noble (Scotland), P. Neergaard (Denmark), and J. de Tempe (Netherlands), the three authors of an annotated list of seed-borne pathogens prepared on behalf of the International Seed Testing Association and published by the Commonwealth Mycological Institute in 1958. All concerned with plant introductions are now aware of the extreme importance of being able to rely on any certificates of freedom of 'seed' from disease or disease-inducing organisms which the export or import regulations of their own or other countries may require, but much still remains to be done in devising reliable tests and in ensuring uniformity in their use. These papers and the discussion which followed resulted in another Conference resolution urging the improvement of seed certification schemes, and the production of seed in areas where the incidence of potentially dangerous seed-borne diseases is at a minimum—a resolution particularly appropriate to the eve of the forthcoming 'World Seed Year' being sponsored by the Food and Agriculture Organization.

The elucidation of epidemiological problems in connexion with plant diseases is dependent on reliable procedures for assessing their incidence, so that data obtained by different observers in different areas at different times shall be comparable. Further, rational and economical control measures are also often dependent on the forecasting of disease outbreaks. E. C. Large (United Kingdom Ministry of Agriculture's Plant Pathology Laboratory) gave a lucid survey of these aspects of the annual outbreaks of potato blight in England during the past twenty years where, due to the close co-operation between the meteorological service and the Ministry, the conditions which determine the progress and severity of potato blight are now better understood than in any other country, and regional forecasting is becoming increasingly accurate. In another interesting paper, L. Ogilvie and I. G. Thorpe (United Kingdom) outlined the co-operative investigation in Western Europe and North Africa of the annual spread of black rust of wheat (*Puccinia graminis*), outbreaks of which in the south and west of England in mid- to late summer have been shown to originate in North Africa in the early spring. At another session, breeding for rust resistance was reviewed in papers from the United Kingdom and New South Wales.

Virus diseases, diseases of various tropical crops, and fungicides were dealt with in a further series of papers and discussions. During the Conference a whole-day visit was made to the John Innes Institute on the occasion of the British Mycological Society's annual plant pathology field meeting, and during the week after the conference opportunities were made for the delegates to visit a number of research stations and laboratories.

G. C. AINSWORTH

# INTRACELLULAR LOCALIZATION OF ENZYMES

A COLLOQUIUM on "Intracellular Localization of Enzymes" was held in Louvain on June 17–18 under the auspices of the Centre Interuniversitaire de Recherches Enzymologiques. The meeting was organized in a similar fashion to that held last year by the same centre on "Specificity in Protein Biogenesis" (see *Nature*, **184**, 1198; 1959). A limited number of papers were read by invited speakers and plenty of time was allowed for discussion. In order to favour an informal exchange of ideas, it was decided not to publish the proceedings of the colloquium. The interest of the meeting was enhanced by the participation of a number of foreign guests to an international symposium organized earlier in the week at the Cancer Institute of Louvain, under the Cell Biology Programme of Unesco, on the subject of "Cell Biology and Growth Inhibition". In addition, the sessions were attended by more than a hundred workers from various Belgian laboratories and by a few visitors from abroad.

The meeting was opened by A. Claude (Brussels), who gave an account of the history of cell fractionation and reported his own recent electron-microscope observations on the cytoplasmic granules of kidney tubules. In the past few years, non-mitochondrial granules have been described under a variety of names in a number of different tissues. Their main characteristic is that they are limited by a single membrane and do not contain cristæ, but their size and internal structure may vary considerably from one tissue to the other and even within the same tissue. Claude proposed the general name of 'cytosomes' for these organelles, and put forward the hypothesis that they may represent various functional states of the same entity, possibly related to lysosomes.

The same theme was discussed later by other speakers, namely, S. J. Holt (London), A. B. Novikoff (New York) and H. Beaufay (Louvain). With respect to liver tissue, the two former speakers both showed excellent evidence, based upon cytochemical staining results and further supported by electron-microscope observations, indicating that acid phosphatase is essentially localized within granules arranged along the bile canaliculi, and previously described under the name of peribiliary or pericanalicular dense bodies. Beaufay reported on recent experimental results obtained with several density-gradient centrifugal systems of high resolution and confirming the association of acid phosphatase with numerous other acid hydrolases, as embodied in the lysosome concept. In agreement with the other speakers, he found numerous pericanalicular dense bodies in purified preparations of lysosomes. However, these preparations also contain a second biochemical component, namely, the granules containing uricase, catalase and D-amino-acid oxidase, which are different from lysosomes, as well as a second morphological component, the so-called 'microbodies', which differ from the pericanalicular dense bodies by the absence of ferritin-like grains and the presence of an internal multi-membranous or crystalloid core. Beaufay suggested that these microbodies might represent the uricase-bearing granules, which are known to contain little or no iron. But evidence to the contrary was produced by Novikoff, who found that the liver of rats injected with bilirubin becomes loaded very rapidly with granules containing acid phosphatase as well as with typical microbodies, which appear to be positive for acid phosphatase in a cytochemical staining test adapted to the electron microscope. It was decided that this point required further elucidation.

A serious discrepancy between biochemical and cytochemical staining results was discussed in detail by Holt, who showed that in fixed rat liver, kidney and several other tissues, esterase, an enzyme known to sediment quantitatively with the microsomes in liver homogenates, shows exactly the same localization as acid phosphatase when revealed by staining techniques. It was also shown, however, that esterase is removed selectively from sections of unfixed frozen-dried tissues by immersion in isotonic sucrose. The possibility thus exists that esterase may be loosely attached to the surface of lysosomes in the cells and be eluted from this site and secondarily adsorbed on the microsomes upon homogenization.

A great deal of attention was also paid to the role of lysosomes in cytolysis and in the accumulation of waste products, as well as to their relationship with pinocytosis vacuoles or phagosomes. Novikoff produced evidence, based on the simultaneous histochemical detection of acid phosphatase and of foreign material taken up by cells, as well as on electron-microscope observations, which strongly suggests that lysosomes may be involved in all these processes. Beaufay reported the results of experiments of P. Jacques, in which the biochemical properties of lysosomes and phagosomes were found to be very similar in many respects, though not identical. In the discussion which followed, it was agreed that the uptake of foreign material by engulfing processes may be followed by intracellular digestion and even possibly excretion of residues, and that a number of the vacuoles and bodies observed morphologically as well as the phagosomes and lysosomes may be part of a general system involved in these phenomena. The exact identification of the granules implicated and of their role will, however, require a great deal of additional work. This session was closed by the presentation of a remarkable film on pinocytosis in tissue cultures by H. Lettré (Heidelberg).

The necessity for correlating biochemical results with accurate cytological data was emphasized by C. Allard (Montreal), who showed that feeding azodyes to rats causes striking changes in the cellular composition of the liver. Bile duct and connective tissue cells proliferate considerably while the proportion of parenchymal cells decreases. Allard reported further that homogenates originating almost exclusively from parenchymal cells can be prepared at all stages of this transformation by pressing the liver through a mesh which retains the connective, vascular and ductular framework of the organ. Enzymic studies performed on these homogenates

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## BRITISH ASSOCIATION MEETING IN CARDIFF

# THE TWO ASPECTS OF SCIENCE*

By Sir GEORGE THOMSON, F.R.S.

President of the British Association

SCIENCE is already valued for what it can do to increase man's control over Nature, and feared for what some of its consequences may be. Some would have us consider these consequences as the sole justification of science. This view, or something very like it, is the official attitude in Marxist countries, and there are many in Great Britain and in the United States who would be horrified to be told they were Marxists but who without any explicit statement do in fact act and speak as if they thought the same. But this view is too limited. There is a second aspect; it is this.

Science aims at understanding the nature of things: in this it is at one with religion and philosophy. But its approach is the opposite. These last try to gain knowledge of the whole, in one case by an awareness of the Deity, intuitive or revealed, in the other by building with words a system of thought which can account for fundamentals. Science starts from the other end. It begins by studying details, often apparently trivial details but things which are queer and appeal to human curiosity. Things like black rocks which attract iron or rubbed amber which makes chaff fly.

This has been more successful than one could have expected. It is a method difficult to defend *a priori*—it has often been made fun of. Swift ridiculed the philosophers of Laputa who studied how to make sunshine from cucumbers. But the method works.

From the study of details such as these come *concepts*. These concepts, or some of them, show vitality and take charge, as characters in fiction are said by authors to do. They are the bases for hypotheses and 'laws', they are the things that get names—mass, energy, temperature, entropy, wave-length, charge, electrons, quantum numbers, to take some examples from my own subject.

Some do not survive: caloric, phlogiston. Others are deposed from their independence and become vassals of the more successful, as mass has of energy or valency of electronic structure.

But the successful concepts—or the best of them—are not concerned with details any more; they penetrate deep in the heart of things. Electrons, for example, are regarded as present in all ordinary matter, and in any attempt to explain the behaviour of matter, physical, chemical or ultimately biological, one is, if one goes deep enough, forced back on to them. At present they stand as a fundamental concept, but even if, as is quite possible, they ultimately come under some still more general idea, the concept of an electron will still be used, as mass is in mechanics.

It unifies our thoughts over a vast area of facts. Thus there is excellent reason for believing that the whole of chemistry is explicable in terms of electrons and the wave functions which describe their location. This is an enormous simplification of thought, even if the mathematics are too difficult to work out in most cases. It does not much matter from this point of view that test-tubes are cheaper than electronic computers if you really want to know the answer to a practical question.

Scientific concepts enable certain aspects of the enormous complexity of the world to be handled by men's minds. They are suggested mostly by experiment but partly by mathematics, and controlled by the need that they should not lead to illogical consequences.

These concepts represent an extension of the human intelligence. They are not easy; many have subtleties which, for example, oblige the popularizer to take anxious care lest in trying to simplify he make statements which are simply untrue. Some are more fundamental than others, but even those which turn out to be only rough pictures of what really happens often retain their usefulness. They are sketches as compared with finished pictures, and if details are not needed a sketch is often clearer.

Concepts are discoveries as well as, indeed more than, inventions. They have more in common with the discovery of America than with the invention of the spinning jenny or of the electronic computer. Some at least have been forced on unwilling minds by hard facts and have resisted many attempts to displace them. I am thinking more especially of the quantum theory.

Not merely are they an exercise of the human mind which equals the brilliance of any system of thought, philosophical or even mathematical, but they represent reality.

The nature of the relationship is to me a mystery, but they are certainly not merely the product of the human mind.

* Presidential Address delivered in Cardiff on August 31 and published in the September issue of *The Advancement of Science*.

Science is a pyramid based on many varied facts, topped with a crown of ideas reaching to the skies. These are its fruit but can change without affecting its stability. I sometimes think that in philosophy the pyramid is the other way up!

What we want as scientists—I am sure in this I speak for the great majority—is that the world should realize that we are not interested merely in making possible new drugs, television sets, or weapons, though all these are important, but in enlarging the bounds of human knowledge.

The greatness of the human race is indeed many-sided. Thus in the world of art there is a difference between the ability to compose or interpret a great piece of music and that which makes possible a great novel or a great picture. Yet all are evidence of greatness and worthy of the name. Still more so is moral greatness. "There is one glory of the sun and another glory of the moon and another glory of the stars."

I have no desire to exalt our profession unduly, but surely the ability to understand, even to a limited extent, the world around him is one of the powers of which man has good right to be proud. Indeed it seems to be the one which most divides him from the animals. The lark's song, the heroism of a plover luring an enemy away from her young, the cat who was seen to attack a grizzly in defence of her kittens—these, if taken at their face value, are notable even by human standards, but I am not aware (though I speak with great diffidence) of any creature which even appears to be trying to discover any general principles.

The chance of understanding things of fundamental and permanent importance is what makes the pursuit of science fascinating and worth while.

These two aspects of science do not in fact conflict. The best way to make advances in technology, whether on the medical or the engineering side, turns out to be to understand the principles. This is quite a recent discovery—indeed it has probably only recently become true. It would not have been much use, for example, to man in the stone age, or even a few hundred years ago, to try to understand the principles of tanning with no basic knowledge of chemistry to guide him. He did better by trial and error. Even the steam engine was developed with little knowledge of the determining principles, though the best scientific minds of the day were much interested, and the thought they gave it advanced science by discovering thermodynamics.

Electrical engineering was the first important activity to be developed from the start on scientific principles, and even here Edison did great things on a decidedly sketchy knowledge. But increasingly more discoveries are made in research laboratories and fewer by workmen on the bench. This is what one might expect. As fundamental principles get known it is possible to use their consequences intelligently. Often these consequences are too complicated to be calculated, but knowledge of the principles is an enormous help by showing in a general way what is likely to happen.

Then of course there are the modern technologies which derive directly from some important new basic discovery, such as electronics and nuclear energy.

This dependence of technology on pure science is now pretty generally recognized by industry. The more progressive industries maintain research laboratories which both make use of the basic discoveries made in the universities and elsewhere, and contribute their own. These laboratories may be owned and operated by individual firms, or be co-operative efforts of an industry in the form of research associations substantially helped by Government. There are black spots of course—industries which spend too little on research or organize it badly—but broadly speaking the need is realized and reasonably well met.

Pure science receives a great return for what it contributes to technology, and this in two ways, materially and in the realm of ideas. Consider first the material return; a modern physics laboratory could not work without instruments developed for technology and obtainable cheaply because industry needs them in large numbers. Take just two examples out of many. The use of high vacua—and how important this is—has been enormously facilitated by the needs first of the electric light industry and then of the manufacturers of radio valves. Again, the complicated electronic devices which crowd every physics research laboratory would be impossible without the cheap components of all kinds manufactured originally for radio and now for television. For this return by industry I sometimes think we academic scientists are not as grateful as we ought to be.

The other influence of technology is more subtle but as important. As science advances, concepts tend to become more and more abstract, further from anything that can literally be touched or handled. To take a simple case, energy is more abstract than mass which it replaces. In the higher flights of theoretical physics abstraction goes much further. Is there not a danger that one may lose touch with reality, and end up by supposing that some elaborate piece of mathematics represents reality when it is only a creation of the mind, inspired indeed by physical reality but no more like it than is a modern picture? I think we are safe so long as the people who make these theories are reasonably close to those who use them, not merely in laboratories but also in industry.

A theory which involves detailed consideration of the behaviour of particles less than a millionth of a millionth of an inch across would have seemed to Swift too absurd to be even worth ridicule. Yet one cannot regard it as a pipe dream when it leads to the great reactors of Calder Hall or Chapelcross. To me, the most amazing thing about science, and the most surprising and exciting fact about our world, is this astonishing connexion between highly abstruse theoretical ideas and the matter of fact, in this case the housewife boiling her kettle with power from nuclei. This surely adds an immense thrill to discovery. I have no sympathy with those who regard technology as intellectually a poor relation of science. To me science without technology is incomplete and inconclusive. Systems of philosophy come and go; some are perhaps true but who can tell? But when conclusions deduced from precise experiments by mathematical theory lead to detailed predictions from which working machines can be designed, machines which without the theory no one would have thought of in a million years, then indeed one knows that one lives in a universe which is rational, and that one has found the key to one of its rooms.

In speaking to you to stress the importance of the idealistic—almost the spiritual—side of science, I am hoping that my words may reach others not

here who are brought less closely into contact with it than are most of you.

May I remind you of a few of the ways in which scientific knowledge has influenced and is influencing thought and the intellectual climate of the world? First and most obvious is the idea of evolution, that things change consistently and pass through successive stages, whether they are mice or stars. That living creatures in particular not only go through individual changes, but also that in the flow of generations changes come over the race, or over a part of it, and that these changes lead to profound differences like those which distinguish men from molluscs. In the year of the centenary of the "Origin of Species" just past, you have heard the profound consequences of this idea described much better than I can.

In the course of my life the quantum theory has produced a revolution in physics comparable with that produced in biology by Darwin. We have been forced, some of us very unwillingly, to believe that at bottom the laws of physics are not statements of what *must* happen, but of the relative chances of a variety of alternatives. That the determinism of the planets, for example, occurs merely because planets are enormous on the atomic scale and their distance from the Sun very large, and that the "Nautical Almanack" would be impossible if the solar system was reduced to the scale of a molecule. Certainty comes with a massive body; or if the bodies are small, one must have very many of them so that the laws of statistics can manufacture near certainty out of highly uncertain events, as they do in life insurance.

This makes quite a difference to the way one regards the world, and I think its consequences are still not realized by the average educated man, though it has been accepted by the majority of physicists for thirty years. It shows for one thing how dangerous it is to extrapolate, to attribute—in this case—to the very small the kind of behaviour that is common sense when one talks of objects of large or ordinary size. That, for example, if a particle crosses a flat screen with two holes in it, it must have gone through one to the exclusion of the other. This is not true of an electron.

The quantum theory stresses another point which is fundamental to the modern view of physics—the importance of the observer. An experiment to be of any use must be observed. True, the immediate observer may be a photographic plate which forms a latent image to be developed and examined later, but there must be something. In other words, the scientist can only learn about the world through his senses. Theories are meant to unify sensations and in this sense explain them, but on these sensations they ultimately rest.

The observer first received proper attention in the theory of relativity. So long as there was supposed to be an æther, there was a privileged observer, or class of observers, those at rest with respect to it. Without it all are on the same footing, and equally entitled to be considered. Now relativity asserts that the laws can be stated so as to be the same in form for all; no privilege is allowed.

But relativistic observers, those rather strange creatures who go about with clocks and measuring rods making signals, are not supposed to alter what they observe. The quantum observer does. Or more precisely, the circumstances that attend observation, for example the light that is required, alter what is observed and in a manner which cannot be determined even after the observation has been made. In consequence the knowledge that can be acquired is limited, because each observation upsets something else one would like to know. This was the first real hint that there are definite limits to scientific knowledge, limits not dependent on human patience or ingenuity. The argument depends, as all physicists know, on the finite size of Planck's quantum of action, but a very similar conclusion might have been reached before the quantum theory was thought of.

I think it is curious that physics remained deterministic in philosophy so long as it did. The power of accurate prediction in all systems diminishes with time. Even for the planets, those most orderly of creatures, a "Nautical Almanack" drawn up for the year 10,000 would be appreciably less accurate than one for next year. When one is interested in individual atoms this loss of accuracy can be enormous and catastrophic. Quite apart from any quantum considerations, even if one knew the positions and velocity of every molecule of a small sample of gas at one instant, one could not predict the path of a special molecule distinguished, for example, by being radioactive; one could not find, let us say, where it would first hit a wall of the vessel holding the gas. Even supposing every gaseous collision fully determinate, a small error in an original measurement mounts up, as Max Born has pointed out, with enormous speed. In a small fraction of a second all the detailed information is useless, and one can only treat the motion as one of diffusion to which only a probability answer is possible. So when time is taken into account one gets much the same result even if Planck's constant were many orders of magnitude less than it is. This kind of virtual indeterminacy is inherent in Maxwell's kinetic theory. It sets as real a limit to certain kinds of human knowledge, even given any thinkable extension of human skill, as does the quantum theory. The circumstances to which it applies are almost certainly of more human importance. The further ahead a prediction is made the less certain it becomes, and beyond a certain rough limit all that can be affirmed is a probability, often over a wide range of possibilities. It is an interesting question, for example, what is the best that could ever possibly be done in the long-range forecasting of weather. Can, say, a prediction of the weather on a particular day ten years hence ever have any validity?

Yet in some respects atoms behave in a surprisingly straightforward way. They pile together almost like spheres, like tennis balls in fact. They are slightly compressible and their distances depend a bit on chemical relationship; but one can place them in order in molecules and still more definitely in crystals. The work which is being done by the group at Cambridge under Perutz and Kendrew is a striking example of this. They have located most of the 10,000 atoms in the vastly complicated molecule of hæmoglobin, the first protein for which this has been done.

Single rows of atoms, and occasionally individual atoms, can actually be seen in the electron microscope. They seem as real, and almost as commonplace, as grains of sand.

In contrast to this matter-of-fact behaviour of atoms, the electrons are strange fairy-like creatures. They have no particular place; even when part of

an atom, one can at best assign them a region in which they are most likely to be found. Unless they have an unusual amount of energy they cannot be assigned a definite path. Even their approximate behaviour is queer and to treat them properly requires highly abstract mathematics.

They can be created out of the energy of radiation but only in pairs with positive and negative charges, and the positive one soon dies in a suicide pact with another negative. In the same way, protons and antiprotons can be created and disappear. Certainly other kinds of elementary particles also have their anti-particles.

I should like to conclude by referring to two ideas of a somewhat more speculative character which may prove of importance in general thought.

The first is the relation between mass, energy and matter. In conventional mechanics, mass is the primary property of matter, even more so perhaps than extension since it is more constant. Now, as is well known, the theory of relativity made it probable that mass is energy considered from another point of view. This is expressed by Einstein's famous equation $E = mc^2$. Thus if energy is added to, or taken from, an otherwise closed system, the mass of the system will increase or decrease, as the case may be, though it takes a lot of energy to make much difference to the mass. Einstein's conclusion has been abundantly confirmed by the discovery of nuclear energy and other experiments in nuclear physics. Further, as I have just said, energy can be transformed into pairs of particles of opposite sign. It began to look as if matter is just another name for energy.

It may seem paradoxical to equate energy with the property, mass, that measures inertia, but remember that in Newtonian mechanics the bullet penetrates because of its inertia, which makes it continue in its state of motion. However, mass is only one property of matter, and perhaps not even the most important. There are indications, rather slight perhaps, but not to be ignored, that matter is *not* just another name for energy. The study of the many curious particles which have been found in cosmic rays and later produced in the giant so-called 'atom-smashers' has shown the persistence of certain features in spite of the bewildering number of spontaneous changes which these particles undergo. Two groups of these particles have appeared such that the net number in each group remains always the same, and this in contrast to a third group for which there is no such constancy. By the phrase 'net number' is meant the difference, in each case, between the numbers of the 'ordinary' particles and of the anti-particles. Thus electrons are members of one group called 'leptons', to which neutrinos also belong. In reckoning the net number of electrons, one subtracts the number of positrons from the number of ordinary electrons. Thus the creation of an electron-positron pair does not alter the net number. The rule states that no interaction between particles of any kind, including the photons of radiant energy and the mesons of the cosmic rays, can alter the *sum* of the *net numbers* of the three kinds of particles, electrons, neutrinos and $\mu$ mesons, which count as leptons. A similar rule holds for the class of particles, protons, neutrons, and some others, which rank as 'baryons'. Leptons can never change into baryons or reversely.

This seems a hint that underlying matter are two classes of entity, each of which indeed can appear in several different forms associated with various amounts of mass, sometimes electrically charged and sometimes not, but yet fundamentally the same. Matter is, I think, more than merely mass or energy. A neutrino has zero rest mass but yet is an entity. A piece of ordinary matter is made up of leptons and baryons in fixed numbers.

The mass of an atom at rest is a form of energy, but matter may be something extra.

This leads to one more instance, my last, of broad ideas derived from physics. It is one of the strangest facts of Nature that she is so fond of whole numbers. The mere existence of large classes of individuals identical in each class such as electrons, protons, atoms of fluorine, molecules of ethyl alcohol and many more is surprising enough. One might expect a continuous gradation of sizes, weights and charges. But it is not so. On the smallest scale only certain types of particles exist. The next most complicated things, atoms, are built of integral numbers of electrons, protons and neutrons. The numbers are fundamental and characteristic. An atom of carbon is a pattern based on the number six, there are six electrons, six protons and six, seven, or eight neutrons according to which of the three kinds of carbon atom it happens to be.

This is such a commonplace of science that one is apt to take it for granted. But surely this, and similar facts about other atoms, are most startling if one thinks. Further, the details of the pattern made by the electrons depend on another set of small integers, the quantum numbers. We cannot say yet whether this is also true of the arrangement of protons and neutrons in the nucleus, but there are indications that it may be. We are getting back to one of the earliest scientific ideas. Pythagoras taught that whole numbers are supreme.

It is worth notice that the masses of the atoms, even reckoned at rest and in the lowest energy state, show only rough regularities. The energy of formation and the mass representing it are variable, and though energy is sometimes divided into units, there is here a continuous variation, for the unit is $h\nu$ and $\nu$ can have any value. Yet even here we have units in a sense, and all photons of the same frequency have the same energy.

Molecules, again, are composed each of an integral number of atoms. It is true that at the moment of a reaction it may be difficult to say which atoms belong to a molecule or even if the concept of molecule is valid ; but few would deny its importance in general. It is a concept which, though it owes something to the desire of the human mind to simplify, yet arises almost inevitably from Nature. If the Martians are competent chemists they will, sometimes at least, think in terms of molecules.

Rather the same can be said of the concept of a cell. Living matter is generally speaking cellular, and the cells that compose a given kind of tissue are mostly pretty much alike in size and shape. Even the organisms that they form tend, at least, to fall into species each containing very many similar individuals. In many cases also the component parts of an individual are multiplied, for example, scales or leaves.

While the 'atomicity' of electrons is perfect in the sense that each is in principle indistinguishable from any other, and the possibility of exchange without resulting difference is built into the theory, the atomicity of members of a species, of cells, and even of molecules is less rigid ; but concepts embody-

ing it are highly useful and represent something real in the world.

At present one can only speculate as to how far the complete atomicity of the elementary particle causes the partial atomicity one sees in biology, or for that matter in astronomy. If it is not a sufficient explanation, then we must look even deeper than the elementary particles for this principle of atomicity, which would make it very fundamental indeed.

I have tried here in a very discursive fashion to remind you of a few of the ways in which science has provided, and is providing, new ideas tied closely to experience, though often experience of a special character. These ideas constitute an achievement of which man may well be proud. It is surely something for beings, so utterly insignificant compared with the smallest of the stars that are scattered with reckless abandonment in the heavens, to be able to understand some at least of the principles which control their existence and enable us to perceive them.

To see these principles as applying equally on Earth, as manifest in the most varied phenomena; in the motions of the tides, in the blue of the sky, in the lightning flash, and in the falling apple; to prove our understanding by creating, on however small a scale, compositions of our own which use these principles in new ways of our own devising; to be beginning to see some light on the nature of living matter and how living forms can transmit themselves to descendants; all these are worth while and worthy to rank with the achievement of sculpture, of music or of literature.

Science is not merely the control but also the understanding of Nature. Its two aspects must be held in equal honour.

# SUMMARIES OF ADDRESSES OF PRESIDENTS OF SECTIONS

## STELLAR MOTIONS

STELLAR motions relative to the Sun are resolved into tangential and radial components. The former appear as proper motions and are seen as displacements of the direction in which the stars are seen. These proper motions, as Dr. R. v. d. R. Woolley in his presidential address to Section A (Mathematics and Physics) points out, are measured by comparisons between new and old catalogues of star positions determined by meridian instruments, and by comparison of new and old photographic plates. They can only be converted into linear velocities in km. per sec. if the star's distance is known. The radial component of a star's motion is directly observed in km. per sec. through the Doppler shifts in the star's spectral lines. Only in the case of the nearest stars can the distance be measured by the direct trigonometric method. In the case of a moving star cluster such as the Hyades, an independent method exists, as the observations of proper motion and radial velocity are consistent within the errors of measurement with the hypothesis that the motion of the cluster stars is equal and parallel. The geometry of this motion permits a determination of each star's distance. Recent measures conducted at the Royal Greenwich Observatory indicate that the dispersion in the velocities of these cluster stars is less than 0·5 km./sec., the total motion relative to the Sun being about 44 km./sec. The permanence of this motion raises interesting questions.

When the velocities of the nearby stars are resolved into three components along rectangular axes, pointing towards the centre of the Galaxy, the pole of the galactic plane and a third axis (tangential to galactic rotation), it is found that the distribution of velocities in each co-ordinate is more or less Gaussian and inferences may be drawn from the three velocity dispersions, which are unequal. Relaxation of the stellar velocities is incomplete. Discussion of the motion perpendicular to the galactic plane leads to a determination of the average density (due to stars, dust and gas) in the solar neighbourhood.

Stellar motions exhibit a number of cases in which stars apparently wide apart in the sky share a common motion. When this can be established, the distances of the stars concerned can be found, even if the stars are too far away for a reliable determination of trigonometric parallax. Some important cases occur, as has been shown recently by Dr. Eggen, of the Royal Greenwich Observatory. A further case of stellar motion is that of the Cepheid variables. These are all too far away to show measurable trigonometric parallaxes, but the average motion relative to the Sun and its dispersion can be found from radial velocities alone. The distances can be found from the period–luminosity relation, apart from a constant multiplier. This constant multiplier can be chosen to make the average proper motion agree with the average radial velocity. The result is a determination of the zero point of the period–luminosity relation among Cepheid variables. This determines the distance of the Large Magellanic Cloud and indeed of all objects including extra galactic nebulæ which contain Cepheid variables.

## CHEMISTRY IS NOT ENOUGH

DR. JAMES TAYLOR reminds us in his presidential address to Section B (Chemistry) that for better or for worse we are living in a society which is based physically on Western science and technology. This has inescapable consequences for the scientist.

To the everyday world science is only a means to an end and not an end to itself. Science is not enough. Chemistry is not enough. Modern societies are pre-occupied with efforts to improve their material conditions. The means which are used depend on the application of scientific knowledge. Only scientists have the necessary training for establishing and using the technologies required to exploit recent major discoveries and those likely to arise in the future. It is clear that they will be brought more and more into technology, and thus into industry, the vehicle by which mankind exploits science for his own ends. It is certain that Huxley's view "that the chief aim of the scientist should be to increase material knowledge rather than human convenience" cannot prevail in modern society, which will be forced to deploy its scientists in a manner conducive to fulfilling its objectives.

The scientist must come down from his ivory tower and play a full part in developing the 'good life'; not merely as a narrow specialist supplying the data of invention, but also in the whole complex of problems which confront us. To prosper we must have an adequate supply of new discoveries and ideas to provide for future progress. In the future such discoveries are only likely to come from the professionally trained scientist and, particularly, the 'academically trained' individual. The laboratory discovery, however, is only one event in a long train which culminates in successful manufacture, and the follow-up involves applied research, development and chemical engineering, in all of which the chemist plays an important and growing part.

While formerly chemical industry was directed by men of non-scientific education, nowadays their place has largely been taken by men with scientific education. Equally important, such men have achieved, in considerable numbers, general and administrative responsibility in financial, commercial, sales and personnel positions throughout the chemical industry, and thus for the first time the scientist is in the position to fashion the ends as well as the means. Scientists are also making an increasing contribution in work study, operational research, analysis of requirements and the study of overheads. In its widest sense the scientists' contribution to industry can be regarded as a philosophy of approach: it is the application of a particular mental attitude which can be shared alike by the scientist, the financier, the salesman and, in the final analysis, the workman.

The scientist and chemist makes his initial contribution via pure science then via technology and industry. He has accepted technology and industry, but finally in the wider world of politics and affairs, where as yet he has neither been accepted nor indeed applied himself, he must deliberately reach out and become an active force. This is his destiny; to this end he was born.

## PLEISTOCENE HISTORY OF THE IRISH SEA

TO-DAY—as in earlier interglacial periods—the Irish Sea forms a water-barrier separating Ireland from Britain. But during the Pleistocene glaciations its basin was a broad dry valley down the floor of which ice from Scotland advanced southwards. It was with this in mind that Mr. G. F. Mitchell (Trinity College, Dublin) opened his presidential address to Section C (Geology).

During a later phase of the last (Weichsel) glaciation, ice pressed up against the mountains of Wicklow and of Wales, and the corresponding deposits can be readily recognized on both sides of the Irish Sea. At the same time a lobe of ice advanced down the Cheshire Plain, discharging its melt-waters into the Severn valley; layers of mud in the melt-water gravels have a radiocarbon age of 42,000 years. At Chelford a deposit of mud, which lies below the deposits of this ice-lobe and contains wood of spruce, pine and birch, has a radiocarbon age of 57,000 years. This mud should thus belong to an interstadial stage within the last glaciation. Nothing is known of the early stages of the Weichsel glaciation in the Irish Sea basin.

A freshwater deposit at Ardcavan in Wexford is assigned to the last (Eem) interglacial period. It indicates temperate conditions and a sea-level no higher than that of to-day. In England also the deposits of corresponding age at Cambridge, Ipswich, London and Selsey all lie close to modern sea-level, and give no positive evidence of a high sea-level around the British Isles during this interglacial period.

During the preceding (Saale) glaciation ice advanced as far as Hoxne in East Anglia, where it deposited Gipping boulder clay on top of the famous interglacial deposit. There was a corresponding advance down the Irish Sea, from the floor of which the ice incorporated marine clays and shells. A calcareous shelly boulder clay (easily recognized in many localities) can be traced as far as Cork in Ireland and Fremington in Devon. This advance was preceded and succeeded by local phases in which ice from the mountains of Ireland and of Wales descended into the Irish Sea valley.

The preceding (Holstein) interglacial period saw the Irish Sea standing perhaps 100 ft. above its present level, and its shores covered by evergreen forest. At Kilbeg, Waterford, trees such as fir, spruce, pine, yew, rhododendron and box were dominant, and the deciduous trees were poorly represented. In Barnstaple Bay the beach deposits below the Fremington boulder clay rise to 60 ft. above present sea-level, while still greater heights are recorded in eastern England at Kirmington and the Nar valley.

In the Weichsel and the Saale glaciations ice advanced far south in eastern England and in the Irish Sea. In the Elster glaciation ice reached the Thames valley, and there must have been a corresponding advance in the west. The younger (Holstein) beach of the Irish Sea contains far-travelled erratics, the transport of which is usually attributed to floating ice. But the glacial seas had their shores far to the south and at much lower levels, and only an ice-sheet of Elster age could have carried these erratics to the levels at which they are now found around the Irish Sea. The Giant's Rock near Porthleven in Cornwall and the erratics of the Cork coast indicate the limits of advance.

For the preceding (Cromer) interglacial period we have no record of the vegetation. But a widely distributed shore-platform shows that the Irish Sea must have stood for a considerable time about 20 ft. above its present level. The beds at St. Erth and the Red Crag shells in secondary position in the Isle of Man and in Wicklow show that there

must have been still earlier marine periods in the basin.

When the ice of the last glaciation retreated up the Irish Sea it deposited three large moraines. The first runs from Wexford to the Lleyn Peninsula about 320 ft. below modern sea-level, the second from Wicklow to the same point 270 ft. down, and the third from north Dublin to the Isle of Man and thence to England at the same depth. The first moraine may have been quickly drowned by the rising waters of the postglacial sea, but the second and third probably persisted for some time, and provided routes for the postglacial migration of plants and animals into Ireland. If the link between Ireland and the Isle of Man was severed before—but only a short time before—the link between the Isle of Man and Britain, then many of the puzzling features of the modern flora and fauna of the Isle of Man find ready explanation.

## TROPICAL CLIMATES AND BIOLOGY

IN his presidential address to Section D (Zoology), Dr. G. S. Carter took as his subject a comparison between the results of tropical and temperate biology, emphasizing especially work in the tropics which has given results not to be expected from our knowledge of temperate biology. As an introduction to his address, he gave a short account of the climatic conditions in the tropics that seem most likely to be biologically important, especially the less-marked seasonal rhythms of tropical climates, and the greater importance of variations in the amount and type of the rainfall in determining the nature of environments.

His first example of biological work in the tropics that has given results unlike those of similar work in temperate regions was investigation of the conditions of life in shallow and stagnant tropical swamps. The waters of such swamps are always markedly and sometimes almost completely de-oxygenated, even close to the surface. This is due to several conditions resulting from the tropical climate and not present in similar temperate waters. Of these conditions the most important are protection from wind disturbance by thick plant growth above the water, absence of overturn in the warm tropical nights, and rapid absorption of any oxygen that reaches the water in the chemical and biological processes of decay at the high temperatures. The faunas of tropical swamps are variously adapted to these conditions. The swamps are the habitat of most of the known air-breathing species of fishes, and the invertebrates show many different kinds of adaptation to life in a de-oxygenated environment.

The distribution of sulphur compounds in African lakes gives a second example of unexpected results in tropical biology. In Lake Victoria and other lakes the sulphur content of the water is very low. But when the mud at the bottom of the lake is examined, it is found that its content of sulphur is extremely high to depths of at least 10–15 m., and, surprisingly, that the sulphur in the mud is almost all in organic compounds. It seems that the fauna absorbs sulphur compounds from the water, which thus becomes denuded of sulphur; the sulphur in their bodies is carried down to the mud when they die; and—this is the surprising feature—the sulphur compounds so brought into the mud do not break down even in the thousands of years needed for the deposition of 10 m. of mud. Sulphur can be returned from the mud to the water only if it is absorbed by the roots of the aquatic plants, which contain a normal concentration of sulphur. No similar situation is known in temperate waters.

The control of seasonal rhythms of breeding and migration in the many tropical environments that are nearly invariable in climate throughout the year is a problem not met with in temperate biology. In equatorial rain-forests the only significant seasonal climatic change is in rainfall, and even in rainfall the variation is more in amount than in frequency, for rain falls at intervals of not more than a few days at any time of the year. Yet even in these environments most species show seasonal periodicity of breeding, and many migrate to other regions at definite times of the year. How these periodicities are controlled and especially whether endogenous rhythms play any part in their control was considered.

Finally, the means by which small mammals are able to maintain their water-balance in desert environments was discussed, and, in conclusion, a plea was made for more work in the wide and still largely unexplored field of tropical biology.

## WELSH EMIGRATION OVERSEAS

PROF. E. G. BOWEN, being head of the Department of Geography and Anthropology at the University College of Wales, Aberystwyth, could scarcely have chosen a more apt subject for his presidential address to Section E (Geography) than "Welsh Emigration Overseas". As he points out, Wales has made a very substantial contribution for its size to the peopling of new territories overseas.

In the main, Welsh emigrants have left their homes seeking employment similar to that which they were accustomed to in Wales. They became farmers, miners, quarry workers and tinplate workers in the New World and in Africa; while in earlier times others had left the homeland in search of religious or political freedom. At present, the majority of Welsh people overseas are engaged in commercial, administrative or educational work. In recent years, the historians have gathered together a considerable amount of information regarding Welsh emigration to individual countries, but no one has yet attempted an overall picture, or examined the matter from a strictly geographical point of view. All this has been made possible by plotting the data assembled at Dolgellau by the Society of Welsh People in Dispersion (Undeb y Cymry ar Wasgar). The overall picture brings out most of the points mentioned above.

Special attention has been directed to the Welsh communities in those countries, such as the United States of America and the Argentine, which lie outside the British Commonwealth. The famous Welsh Colony on the banks of the Chubut River in Patagonia is studied in some detail, and much new evidence is made available concerning the prepara-

tions made for the great adventure in the middle of the past century, and the extent to which the Welsh emigrants were misled before they left their native land, concerning the geographical conditions they were going to find in their new homeland in the South Atlantic.

## MONETARY THOUGHT AND MONETARY POLICY IN ENGLAND

THE purpose of Prof. R. S. Sayers's presidential address to Section F (Economics) is to review the theoretical approach to the problems of monetary policy, in the light of changes in the institutional and political environment. It is confined to questions of internal policy: the theory is that of a closed system.

Since 1800 all policy has been based on a broad quantity theory approach: a simple supply-and-demand analysis, in which money is regarded as basically different from other commodities. Although the abstract sense of money, as the unit of account, is unambiguous, money in the concrete sense—the medium of exchange—has no parallel sharpness. It is impossible to identify money either by reference to use, or by the absence of interest, and the distinction between active money and idle money is only notional and may mislead.

For the purposes of policy we have to think of the pressure of total demand, and for this purpose all claims potentially useful for incurring market commitments are relevant. This includes the gross volume of trade credit, variations in which can dwarf variations in bank credit. Non-bank credit has no regular proportionality to bank credit. If all these problems are re-formulated with the use of the conventional concept of velocity of circulation, the conclusion remains the same, and there remains the question whether any disturbance sets up equilibrating forces.

The question of the relation between an acknowledged kind of money and other assets with some monetary quality has been debated continually since 1800, sometimes (as in the 'Currency School' period) with great vigour; these controversies are reviewed in some detail. It is argued that the equilibrating mechanism depended on the power of bank rate to instil fears of trade depression, that during a long period this mechanism was overlaid by the extraordinary power of bank rate over the foreign exchange situation, and that the power has been undermined by the 'full employment' policy.

In the inter-war period more attention was given to the equilibrating mechanism, and ideas about the function of the rate of interest in this mechanism were developed particularly by Keynes. These developments in monetary thought are briefly reviewed, and it is shown that the formulations then used continued to depend on the notion that the supply of the means of final payment was of critical importance. The dangers of this kind of analysis have since been underlined by the development of financial intermediaries and by the behaviour of trade credit. In a rising boom, the sources of liquidity broaden, and the rising demand for the means of payment comes too late and is too easily satisfied.

These developments have tended to make the banks relatively less influential, and to narrow the basis on which direct authoritative action has traditionally been imposed. This negative conclusion is the most important of the examples given to show how the shape of theoretical analysis bears upon the practical problems of policy.

## STATICS AND THE ENGINEER

SIR ALFRED PUGSLEY'S presidential address to Section G (Engineering), which is prefaced by an indication of the notional difficulties that arise in statics when divorced from engineering and is closed by an emphasis on the power and grace of statics, touches on the interests of schoolboys, mathematicians and engineers alike.

An introductory section brings out the way in which mathematics, and particularly statics, entered into constructional engineering, and seeks to show how the relation between theory and practice in engineering has changed from one in which mathematicians were imposed on engineers to one in which, at least in statics, engineers themselves embrace the theory and seek to advance it.

The outcome of this change is then illustrated in some detail by reference to developments in applied statics in a number of fields. The new understanding of solid friction is seen as the result of a replacement of the smooth rigid body notions of classical mechanics by the realistic, rough and deformable-body ideas of the engineering subject of strength of materials. The limitations of nineteenth-century methods of analysing frameworks, based upon classical statics, are seen to fade before the more general energy methods of this century, linked with ideas of elastic strain-energy; and these energy methods are themselves seen to develop—albeit hesitantly—in the hands of engineers. Some attention is also given to the efforts of engineers to achieve economy in the arrangement of their frameworks.

It is an easy transition from the problems of the plane and space frames of great bridges and airships to those of modern suspension bridges. Here there is added to the usual linear problems of strain energy a non-linear gravitational energy problem due to the great weight of the bridge itself compared with the applied loads arising from crossing traffic.

The development of statics for and by engineering works is further illustrated by the problems that arise in the thin tubular structures of ballistic missiles, the reinforced shells of submarines, and the bathyscaphe cabins of Piccard and his successors for deep-sea exploration. The static stability problems of such tubular and shell-like structures are briefly examined and seen to present new challenges for the future.

## THE PEASANT AND THE PAST

PROF. ESTYN EVANS, in his address to Section H (Anthropology), spoke of the peasant and the past, and the significance of present-day folk-life studies for the interpretation of archæological evidence and the better understanding of the food-producing societies of Neolithic and later times. An intense interest in the whole past of man on Earth was a feature of the present age, stimulated on one hand by a growing sense of world unity, and on the other by discoveries which had brought the means of giving precision to the chronology of human history in

periods before written records were kept. Some peasant values appeared to be so universal and resistant to change that they may help to illuminate the past. The term peasantry, stripped of its sentimental associations and derogatory implications, could be defined as a traditional society for whom farming was a way of life and not a business investment. It was a part-society standing in a two-way relationship with an élite which was normally an urban society. It had to be sufficiently stable and technologically advanced to be worth exploiting in one way or another, and possession of the plough and traction animals, with distinctive regional types of settlements and field-systems, were normal concomitant features. These indices were traceable by archæological methods, and it could be shown that peasantries or near-peasantries were of long standing in many parts of the Old World. Interpretation of the material evidences of archæology could be supplemented by the use of parallels drawn from folk-life studies among surviving peasantries.

Ecological studies of peasant societies were badly needed. Social anthropologists had tended to devote their attention to 'primitives' and they were often so pre-occupied with such matters as kinship that they paid inadequate attention to variations in economy, technology and society in relation to environment. It was dangerously easy to find isolated analogies between societies far removed in space, and it was more profitable to investigate regional examples before trying to establish universals. In an attempt to trace continuities by using evidence drawn from folk-life studies and archæology, Prof. Evans took Ireland as his example, a region where the archæological record was relatively short and complete, where a vast amount of oral tradition was available, and where peasant folk-ways had not entirely succumbed to the accelerated forces of change. It was sometimes objected that such local studies, by seeking continuities, could lead to the false conclusion that civilization was indigenous. They might, at the worst, breed parochialism and a narrow nationalism. "In groping backwards through our own past," said Dr. Evans, "it is important that we should not ignore the warning light brandished, however provocatively, by the diffusionists, and so fall into the trap of regarding civilization as the product of local evolution."

In fact, folk-lore tended to focus its attention on the periods and phenomena of contact and could thus provide a guide to acculturation. At such critical periods folk-lore and folk-ways tended to be revitalized, though they usually changed their forms in the process. Or outmoded ways, driven underground, assumed magic powers, and many curious survivals provided clues to practices that were probably once widespread. The establishment of more folk-museums as instruments of record and research was urgently called for.

Prof. Evans concluded by directing attention to the relevance of such research to the theme of the Cardiff symposium on world food supplies and population. Perhaps two-thirds of the world's population were primary food-producers at, or not far removed from, peasant-levels. Their practices and values were often out of step with the modern world, but in many areas improved standards of living could be obtained with least disruption by respecting the institutional framework of peasant societies. We should know more about them before they are finally transformed and lose their links with the past.

## PHYSIOLOGY OF HEARING

IN recent years considerable advances have been made in auditory physiology, especially that of the internal ear. At present, also, there is increased interest in noise as an environmental factor, stimulated largely by the introduction of turbo-jet aircraft into commercial operations, and questions are frequently raised on the possible effects of noise on health, working efficiency and hearing. The time was thus opportune for Prof. W. Burns to choose "The Physiology of Hearing" as the subject of his presidential address to Section I (Physiology and Biochemistry).

Considering first the physiology of the peripheral mechanism, the chief interest resides in the mechanism whereby the ear attains its astonishing degree of sensitivity, such a large dynamic range, and how it can act as a peripheral resolving mechanism for different levels of sound intensity and for different frequencies of sound. The original brilliant theorizations of Helmholtz, and the contributions of Rutherford and others, have now been put to the test of rigorous experimental investigation, using refinements of technique and new approaches, especially those made possible by electronic means. The mechanism of the middle ear and the movements of the structures of the cochlea of the internal ear, as a result of sound stimuli, have been established beyond doubt by the series of brilliant investigations, carried out over a period of years, by G. von Békésy. He has shown by direct microscopic inspection by normal and stroboscopic illumination that the movement of the basilar membrane and associated structures, collectively known as the cochlear partition, essentially takes the form of travelling waves of transverse displacement. These originate at the base of the cochlea and travel towards the apex, in response to sound stimuli. These waves of displacement increase in amplitude, reach a maximum, and then rather rapidly die away. The position of maximum amplitude is broadly determined by the frequency of the causal sound, the high frequencies near the base, and lower frequencies near the apex. The lowest frequencies involve the whole cochlea.

These findings, although they do not substantiate any of the earlier theories, do imply a form of resonance, albeit a rather broad and unselective one, which is capable of performing a somewhat low-grade form of frequency analysis at the periphery.

The means whereby this resonance pattern is transformed into nerve impulses has been intensively investigated, especially at the Central Institute for the Deaf at St. Louis by Hallowell Davis and his collaborators. In a long series of investigations, the findings of Békésy on the vibrational patterns of the cochlea have been confirmed by electrical means and much new information of outstanding importance has been obtained. It now appears that the electrical positivity of the scala media with respect to other tissues is maintained by metabolic activity of the groups of cells known as the stria vascularis, and that this potential represents a store of energy which can be released for the purpose of stimulating the auditory nerve endings when the organ of Corti is moved by sound vibrations. The potential changes known as the cochlear microphonic and its associated potentials, called by Davis summating potentials, now appear to be derived from movements in various directions of the hair cells by displacement of the hairs. These displacements are caused by relative

movement between the upper surface of the organ of Corti and the overlying tectorial membrane, in which the hairs are embedded. The anatomically distinct group of hair cells, known as the external hair cells, appear to have a separate function and lower thresholds compared with the external group of hair cells. The cochlear microphonic potentials seem to originate solely from the external hair cells; these potentials are an electrical transcript within limits of the sound stimulus, and together with the summating potentials which, in part, originate from the internal hair cells, appear to act as the stimulus for the action potentials of the auditory nerve. It is now becoming clearer how the information on intensity and frequency of sound is coded in the auditory nerve and that further resolution is added by the activity of synaptic mechanisms higher up the afferent pathways to the brain centres.

In considering the effects of noise on hearing, as distinct from its effects of working efficiency or peace of mind, difficulties arise because of the complexity and variety of different noises, and the variability in susceptibility to hearing damage in different people. However, three types of effect of noise on hearing can be distinguished. Noise may produce temporary threshold shift, which is a reduction in sensitivity lasting for months, hours or days, as a result of exposure to sound. The reduction in sensitivity affects frequencies, in general, higher than those which caused the temporary effects, and this is clearly demonstrable in the case of pure tones, although wide-band noise shows the same tendency. Most of the temporary threshold shift is acquired in the earlier hours of a day spent in noise. The second effect may be called 'acoustic trauma'; and it may arise from short exposure to very intense noise, to a sudden explosive sound. Various degrees of permanent hearing loss, accompanied by some temporary loss, result. The third type is occupational hearing loss, in which daily exposure to noise in the course of work may eventually, perhaps after many years, produce permanent losses of hearing of various degrees. In this case temporary threshold shifts will also occur, but when these have passed off, residual permanent losses can be found. Occupational hearing loss tends to occur at the higher frequencies, and may be detected by an audiometric examination long before it is subjectively noticeable, or any social disability has occurred. Neglect of such signs, or continued exposure, however, will result in a progressive involvement of the lower frequencies, including those used for speech recognition, and if this is so the person will become aware, as will his family, of difficulties in understanding normal conversation.

Loss of hearing due to occupation occurs only in certain noise conditions and in certain people. Significant loss is avoidable by the use of certain measures which are not difficult, but may be tedious and time consuming. These measures include the measurement of the noise exposure in terms of intensity, frequency and duration; and the measurement of hearing. The assessment of hearing loss due to noise must take into account various personal factors, including age, to allow for the normal deterioration of hearing with advancing years. The greatest need at present is for more research into the precise relations between the different characteristics of noise exposure and the effect on the ear. In the meantime, tentative relationships are used in deciding whether a given response to noise is, on average, harmful and whether noise reduction, hearing protection, or other means should be used. However, better knowledge in this field will enable more precise and efficient hearing conservation to be practised.

## EXPERIMENT IN PSYCHOLOGY—A CENTENARY AND AN OUTLOOK

THE publication, in 1860, of Gustav Theodor Fechner's "Elemente der Psychophysik" is commonly taken to be the starting-point of experimental psychology. Prof. R. C. Oldfield, in his presidential address to Section J (Psychology), traces some features of the subsequent history of the subject and referred especially to inter-relation of theory and experiment.

Fechner, he said, was an outstanding innovator. He introduced the stimulus–response method, made physical measurements throw light on psychological problems and systematized statistical and experimental design. Psychophysics was one of the first branches of biology to make use of quantitative methods. It was Fechner's misfortune to initiate a period of controversy over the problem of measuring sensation. Hermann Ebbinghaus, in his work on memory, shares with Fechner the distinction of first revealing simple quantitative relationships among phenomena at the psychological level. In both cases the outcome of their work is independent of its particular *rationale*, and its interpretation is still a matter of active inquiry. Bartlett's studies of memory, on the other hand, illustrate the usefulness of experimental work not constrained by the more rigid canons of laboratory procedure, and emphasize both the advantages and the dangers of introducing *ad hoc* concepts. These dangers are more evident still in the activities of the *Gestalt* school, though their brilliant record of novel experiment, and the decisive overthrow of gratuitous preconceptions regarding perception which they brought about, gave tremendous fresh impetus in a wide field of research.

More important, probably, in the long run, were the developments which led to the establishment of physiological and comparative psychology on a scientific basis. Watsonian behaviourism itself had at least the merit of provoking controversies which, when they had subsided, allowed a fresh start on a simpler and more direct basis. But the vital step was taken when S. I. Franz, in 1902, combined the quantitative systematic methods for the study of animal behaviour devised by Lloyd Morgan and Thorndike with the cerebral ablation techniques developed by the experimental neurologists of the nineteenth century. Following the extended pioneer work of Lashley, these forms of experiment are now proving remarkably fruitful, not only in the field of cognitive, but also of appetitive and affective, functions. Progress in these directions can be gained without the need for elaborate theoretical constructs. The importance of the psychologist keeping closely in touch with anatomical and physiological factors, Prof. Oldfield suggests, does not primarily lie in the immediate hope of explanations of psychological functions in these terms, but in maintaining theoretical simplicity and in bringing to light fresh phenomena for fruitful study.

Systematic observation of, and simple experiment on, animals behaving in their natural habitat, so extensively developed by the 'ethological' school, has formed the natural and fruitful complement to laboratory studies. The theoretical formulations of this school have proved less rigid than they initially appeared to be, and much may be expected by cross-fertilization between laboratory, and field, observation.

The possibilities of experiment on human beings are, however, not being neglected, and Prof. Oldfield gives one example, from the field of speech and language, where a fresh theoretical approach and new technical resources have led to rapid progress, with extension into other topics such as attention, where a century ago effective quantitative experiment would scarcely have been thought possible.

In concluding, Prof. Oldfield makes a number of observations about the prospects of experimental psychology. The most important factors making for good progress in the immediate future he believes are avoidance of parochialism, full and free collaboration between psychologists and workers in other relevant fields, the attraction of more young people of first-class ability into the subject and the provision of the right atmosphere for them to learn in as undergraduates and as graduate research students. He thinks that the future of the subject will be that of a biological discipline, destined one day, perhaps, to be instrumental in extending the present range of fundamental biological conceptions. The next hundred years promise exciting developments. But, feeling that there is little present evidence of any real wish on the part of human beings to understand themselves, he is unwilling to predict what their impact on people generally may be.

## ORIGIN OF ANGIOSPERMS

ATTENTION was directed by Prof. T. M. Harris, in his presidential address to Section K (Botany), to the fact that fossil botanists have had notable success in bringing ancient plants to light, when they happened to have good material to study. They have been much less successful when they have directed their research to answer a specific question. Their longest sustained effort has been to discover the early ancestors of the flowering plants (Angiosperms), and here they have failed almost completely. The main thing that can be claimed on the credit side from much devoted research is that the fossils which they hoped they would be able to establish as ancestral flowering plants have been proved to be so different that no one now so regards them. Instead, they are representatives of extinct and strangely organized plant families. Progress has been made, but not in the way intended.

Unequivocal knowledge of some early flowering plants would not only satisfy the fossil botanists' desires; it would also have a profound effect on the botany of living plants. In two plant groups, the ferns and the conifers, the right sort of information is at hand from fossils; instead of interminable discussion there is simple agreement on the numerous botanical problems where the fossils tell a clear story.

In fact, little more is known now about the fossil history of flowering plants than in 1860, but what was a doubtful boundary of knowledge then is now a clear boundary. It was then known that fossil flowering-plant organs, leaves, wood, fruits, seeds were common throughout the Tertiary period and as far back as the Cretaceous period, but they ceased rather after the Middle Cretaceous. Before that there were plenty of ferns, conifers and other plants, but very few that suggested a flowering plant. Those few which did suggest one were afterwards taken up enthusiastically for study and shown to be nothing of the sort. Each decade has provided one or two new candidates, and most have since been rejected as the result of much hard work.

Fifty or a hundred years ago it was suggested that the flowering plants evolved in remote and geologically unexplored regions, perhaps near the North Pole, or perhaps on an isolated island, like New Zealand. Then, in the Cretaceous, geographical changes allowed them to escape and to spread over the Earth's surface and presently to exterminate most of the previous flora. As more is learnt, this kind of explanation becomes less likely; there is evidence now, for example, that the flowering plants arose at about the same time and in much the same manner in New Zealand as in Britain. There is, indeed, a current idea that they dominated the land a little earlier in the tropics than in high latitudes; but it is not yet agreed where the Cretaceous poles and tropics lay. There is, too, a current theory that they evolved first in dry and upland regions, the fossils of which are seldom preserved. These theories are, in part, excuses for failure and what is needed more than excuses is a hypothesis which is a recipe, if not for success, at least for vigorous work. It seems, too, that the days of these theories may be numbered now that fossil-pollen is being so widely studied. Pollen blows far, and if the flowering plants were anywhere in force before the Cretaceous it should be possible to find their pollen. So far, what is known is that their kind of pollen appears and increases at the same time as the leaves, or only a little earlier. Before the Cretaceous, there are a few claims for flowering-plant pollen grains, but then there are a few debatable leaves and other organs.

A hypothesis that does make for progress is that the ancestors of the flowering plants were present in the regions that have been studied and that they have been collected, but they have been unrecognized because they are not like modern flowering plants and have been wrongly classified. Anyone looking at a fossil flora where everything is neatly classified might think this preposterous; but, in fact, nearly all fossil genera are based on a single kind of organ known in isolation. Its classification is not secure, but merely tenuous reasoning from very scanty evidence. The genera of the text-books are the minute percentage of fully known ones.

These early fossils should be studied, not as early angiosperms, for that is to invite disappointment, but for whatever can be learnt about them. The new facts will provide surprises; that is, sometimes things will be found so new as to be contrary to expectation. Prof. Harris pointed out that nothing is more contrary to his own expectations when he studies a little-known fossil of pre-Cretaceous age that it will prove to be a flowering plant, but since it is almost unknown almost anything may happen: therein lies hope.

## THE DANGEROUS CONCEPT OF THE NATURAL FOREST

RELATIVE to agriculture, forestry is still a very young science. The bulk of the world's timber still comes from natural, rather than managed, forests. This being so, it is perhaps not surprising, as Mr. T. R. Peace points out in his presidential address to Section K* (Forestry), that foresters should tend to turn to the natural forest as an ideal toward which they ought to aspire. Many mistakes have been made in the creation of artificial forests, and a tendency has developed to attribute these to departures from natural forest conditions. No one would deny the desirability of more research on forest relationships, but there is no need to evaluate these relationships on the basis of their occurrence in the natural forest. The agriculturist no longer bases his practices primarily on the behaviour of wild plants, and it is certainly necessary to consider whether the forester should do so.

A managed forest, in so far as timber is being removed from it, is inevitably different from a truly natural forest. In fact, there are normally many other differences, especially if the forest is planted. The forester often uses trees which are exotic to the area in which he is working. He usually creates even-aged and often pure forests, whereas natural forests are nearly always uneven-aged and mixed. The forester can improve his forest sites by practices such as ploughing and manuring. He can also improve his crops by selection of species, provenances or individual trees of especially high quality.

Believers in the natural forest tend to decry the use of exotics; but exotics have been planted successfully in many countries, especially in Britain. In any event, the conception of exoticism is based on a misunderstanding of the bases of the natural distributions of plants.

While it is admitted that pure crops inevitably present certain enhanced disease risks, it is clear that they have certain sylvicultural advantages. It should not be assumed that their disadvantages, where these occur, cannot be overcome by appropriate techniques.

From a production point of view, uneven-aged stands have very definite disadvantages. If one does not accept the concept of the inherent desirability of the natural forest, it is hard to find any good reason for their retention.

Admittedly, the use of pure coniferous crops may possibly have undesirable effects on forest soils. It is, however, clearly necessary that this effect should be better understood and evaluated, before admixture of broad-leaved trees is generally advocated. In this connexion, it is considered that the influence of mycorrhiza has often been exaggerated.

The study of the biological relationships of the natural forest will provide valuable data towards our understanding of forest relationships in general. It is, however, highly undesirable that the conditions existing in the natural forest should automatically be regarded as ideal, and any departures from them as retrograde steps.

If we are to make that progress in the acquisition of knowledge, which is necessary for a proper understanding of forest processes, it is dangerous to limit ourselves at this stage by putting forward general principles, even if they appear to have a sound foundation. To burden ourselves with a concept so vague as the general desirability of the natural forest is doubly dangerous.

## SIXTY YEARS OF PROGRESS IN ENGLISH EDUCATION

IN his presidential address to Section L (Education), Prof. H. C. Dent points out that in 1900 England was educationally a sadly under-developed country. But the first decade of the twentieth century was one of explosive reform in many directions. Responsibility for all public education was for the first time vested in a single central authority by the establishment of the Board of Education, which took over in 1900. The Education Act, 1902, transferred local responsibility for public education from *ad hoc* school boards and voluntary bodies to the county and county borough councils, and, by granting them powers to provide and aid education 'other than elementary', created a statutory system of secondary education. This system was expanded rapidly, and its social range greatly widened by the introduction of the 'free place' scheme in 1907. Meanwhile, between 1900 and 1909 the number of universities in England was doubled.

Local education authorities were in 1906 empowered to provide school meals for necessitous children, and in 1907 required to set up a School Medical Service—a reform which within a generation effected a revolutionary improvement in child health.

The First World War focused attention on the exploitation of young workers. Though the attempt, made by the Education Act, 1918, to establish post-school day-continuation schools proved abortive, this Act established fourteen as the school-leaving age without exemptions, thus abolishing the 'part-time' system; and by requiring local education authorities to provide advanced and practical courses for older children in public elementary schools, paved the way towards secondary education for all.

A decisive step was taken towards this by the first Hadow Report of the Consultative Committee of the Board of Education, "The Education of the Adolescent", published in 1926, which presented the concept of education as a continuous process conducted in successive stages, of which the first, up to the age of eleven plus, should be regarded as 'primary' education, and the second, available to all, but in different forms to match different abilities, as 'secondary' education. Uneven but unceasing advance towards this ideal was made up to 1939 by 'Hadow reorganization'—the provision of separate schools for primary and post-primary education within the public elementary system. Further reports by the Hadow Committee, published in 1931 and 1933, offered blueprints of curriculum and method for the junior and infant sections respectively of the primary school. These are the bases of contemporary practice.

The Second World War initiated another era of explosive reform. The Education Act, 1944, re-organized the statutory system of public education into progressive stages, and established the principle of secondary education for all. Concurrently, there began an expansion of university and other higher education which bids fair to be without precedent in our history.

We are still in the earlier stages of the present advance. Perhaps more remains to be achieved than has been so far, especially in the sphere of quality. But what has been done since the War should not be under-estimated; it is a very remarkable achievement. The next ten years are likely to prove absolutely crucial, for within them we must match our man-power with our ambitions—we have not yet successfully done so.

## PASTORAL SYSTEMS IN RELATION TO WORLD FOOD SUPPLIES

DR. WILLIAM DAVIES, in his presidential address to Section M (Agriculture), directed attention to the fact that world pastoral systems can be classified into five groups: (1) very intensive (supporting 80 cattle units per 100 acres), being typical of the best in Great Britain or New Zealand; (2) intensive (40 cattle units per 100 acres), the average in Great Britain; (3) moderately intensive (20 cattle units per 100 acres), typified by marginal grasslands in Great Britain; (4) extensive (10 cattle units per 100 acres), typified by ranching in the United States; and (5) very extensive (3–5 cattle units per 100 acres), which is typical of the extensive cattle ranching in Africa, Australia and the Americas.

International production data, as published by the Food and Agriculture Organization, are used to estimate the present stock carried in the various pastoral regions of the world. These data are reduced to the basis of a standard cattle unit, the latter being based on data collated and published by the British Grassland Society (1955). In the figure for cattle units all classes of domesticated grass-eating animals are included, for example, cattle, buffalo, horses, camels, mules, asses, sheep and goats.

Two-thirds of the area under 'grassland' in the five continents is occupied by extensive pastoral systems, and these carry about one-third of the total of the world population of grass-eating animals as calculated to a standard basis of cattle units. At the present time grass-eating farm animals total nearly 900 million cattle units for the world as a whole. Half of these are found within the 'tropics' (here defined as 30° N.–30° S.). These produce one-third of world meat supplies, one-fifth of the milk and other dairy produce and a large portion of the hides, skins and animal tallow in world trade.

Each pastoral system is examined, first in the *status quo* and then in terms of potential as suggested by the findings of grass/animal research and experimentation within each zone concerned. Very large and economically important advances have already been made as regards the improvement of grassland and increased output of meat and milk within the intensive pastoral systems of Europe, America and Australasia. Much research activity is in progress which suggests that yet greater advances in output from grassland are easily possible in the not too distant future.

As regards the extensive pastoral systems, few or no detailed grassland researches have been made until recently when Australia and East Africa in particular have caused such work to be initiated, already with notable advances. On the basis of the findings of currently conducted research there is evidence which suggests that large increases in total output of animal products are possible both technically and on the basis of economic profitability. If this proves true, then very large aggregate additions can be made to the world supplies of meat and milk following sound measures of grassland improvement on the ranches of the world.

The need is for agronomic research into the grass/animal/soil complex and particularly in extensive pastoral zones. There exists a serious paucity of both research and advisory agronomists. Farmers as well as governments everywhere must be made cognizant of this position, for if the world is to be fed adequately, there must be an increase in numbers and in gross outputs of farm animals. The answer lies in the steady improvement of grassland, animal and also of soil in every continent. This requires well-planned research and advisory services which are the intimate concern of adequately trained grassland agronomists who can offer sound guidance, but who must have the full support of governments and of the agricultural industry everywhere.

## POPULATION GROWTH, FERTILITY AND POPULATION POLICY

IN his presidential address to Section N (Sociology), Prof. D. V. Glass remarks that although we are concerned with the population problems of to-day and of the near future, discussion is so often linked with the name of Malthus that it is desirable to re-examine the context in which Malthus wrote, and to consider whether his recommendations have any relevance now.

Malthus was far from opposed to population increase as such. His concern was with the *rate* of increase, and his recommendations aimed at reducing that rate by delaying marriage. He was opposed to birth control, not only on moral grounds but also because he regarded the 'tendency' of population growth to press upon the means of subsistence as itself a stimulus to individual industry and to social and economic progress. Birth control, he believed, by enabling parents to decide upon the number of their children, would remove that stimulus.

Since Malthus wrote, the main elements in his argument have been largely discarded. Both public and private morality have come to accept birth control. The Catholic Church now accepts responsible parenthood and family planning, though only by abstinence and by the use of the 'safe-period'. Events have also shown that population pressure is not necessary as a stimulus to individual or social action. It was Malthus's successor at the East India College, the Rev. Richard Jones, who saw that it was not primary wants for food, but the secondary wants—capable of indefinite extension—which would constitute the brake on population increase. The intervention of birth control has not reduced the power of this brake; on the contrary, it has been enabled to act with greater effectiveness.

Further, when Malthus wrote, he was concerned especially with Britain, and with the possibility that rapid population growth might lower levels of living. Growth-rates were not, in fact, very rapid in relation to technological development at the time. To-day, in under-developed countries, growth-rates are frequently greater than 1·6 per cent annually. Further, the much more powerful means of reducing mortality

may well raise growth-rates above 2 per cent per annum during the next two or three decades. At the same time, levels of living are so low that the first priority must be to raise them rather than to control population growth. Moreover, most economists regard that as possible. Though they view rapid population growth as a hindrance, they do not consider much slower growth an indispensable prerequisite for improving the levels of living in under-developed societies.

Higher levels of living are also necessary if population increase itself is to be re-adjusted. It might appear easier for birth control to spread in under-developed societies to-day than it was in the West during the nineteenth century. There is not the same degree of opposition from organized religion, and some governments have adopted policies for encouraging the use of birth control. But in the present context, the pressures in under-developed societies are not such as to induce many couples seriously to limit the size of their families. Though there is a generally 'favourable' attitude to birth control, positive interest often does not develop until couples have had four children. The fall in the birth-rate in Japan since the Second World War, though it has taken place against a background of official policy and of official and unofficial publicity, is not an example of what can be achieved by persuasion alone in under-developed societies. For in many essential respects, Japan is a highly developed society, with an advanced technology. Moreover, unlike India, Japanese tradition as such involved the control of population growth. Rapid economic and social change is needed if levels of living are to rise substantially in the face of rapid increase of population. Such change is also needed to provide the basis for new aspirations, without which the re-adjustment of population increase itself is unlikely to take place.

## SCIENCE BROADCASTING IN SOUND AND TELEVISION

MR. A. B. OLDFIELD DAVIES discusses in his presidential address to Section X (Assembly of Corresponding Societies) the scope and form of science broadcasting in sound and television. Science broadcasting ranges from incidental references to scientific matters in magazine programmes like "At Home and Abroad" and "Matters of Moment" (sound) and "To-night" and "Panorama" (television) to more direct attempts at conveying scientific information by means of regular series of science broadcasts, the oldest established of which is "Science Survey". With a wide appeal because they deal with out-of-doors matters are various programmes on nature study, rural lore and astronomy. In addition to what may be called the staple fare of science programme' in television, of which the series "Eye on Research's is a regular ingredient made notable in 1960 by two special series intended as a prelude to the tercentenary celebrations of the Royal Society, there are the single, quite ambitious, even spectacular, programmes on subjects of current scientific importance once or twice a year.

In science broadcasting, as in all broadcasting, it is necessary to be clear as to the nature of the audience to be reached. Here sound broadcasting with its four domestic programme services has a range and flexibility denied to television which has not the same facilities for catering for minority audiences. The British Broadcasting Corporation's schools programmes, which pay considerable attention to science, are a clear example of catering for a particular audience, which looks and listens under conditions which are known, the pattern and purpose of the broadcast being the result of close consultation with various educational bodies. Here, too, the broadcaster can rely on the teacher to ensure that what is broadcast is likely to be grasped and understood. There is also consultation with outside bodies and individuals in planning adult programmes, but it is more spasmodic. There is no regular channel. Should there be a science advisory committee as there is a music or an agricultural advisory committee? Should there be in the British Broadcasting Corporation a department of science as there is for drama, music and religion? But science is not something which comes to life when it is performed. What is important is that there should be qualified scientists on the staff who are dedicated to the important job of communicating through sound and television broadcasting. Being a scientist is one thing, being professionally keen on communicating especially in terms that the masses understand is another. A person combining these qualities is not easily found. Yet more and more scientists are ready to communicate through broadcasting. In the six months of last winter more than a hundred different scientists took part in science programmes, not counting twenty-five scientists who broadcast in the Welsh language during the same period.

To assess the effectiveness of science broadcasting is not easy. The British Broadcasting Corporation's Audience Research Department helps to obtain the kind of information which a theatre or concert manager gets from his box office returns, or from the immediate reaction of the audiences to what is offered them. There are certain imponderable results which might become apparent over a period: general appreciation of the work of scientists, some notion of what they are after and the spirit that animates them, and a growing respect for knowledge as something good in itself.

# THE CARDIFF REGION

## The Cardiff Region

A Survey. Chairman of the Editorial Committee: Sir J. Frederick Rees. (Prepared for the meeting of the British Association held in Cardiff, 31 August to 7 September, 1960.) Pp. xv+222+24 plates. (Cardiff: University of Wales Press, 1960.) n.p.

IN the words of Sir Frederick Rees, the chairman of the editorial committee of "The Cardiff Region: a Survey", "During the last forty years great changes have occurred in the region and in our detailed knowledge of it. This survey endeavours to record some of these". The period of forty years is mentioned since the British Association last met in Cardiff in 1920. It also met there in 1891.

Thirty-two contributors, mainly from University College, Cardiff, have produced a volume full of information for the members of the Association. There are sections on landscape and climate; geology; botany; zoology; archæology; history; population; industrial structure; agriculture; the Welsh language; place-names; the literary tradition in Latin, Welsh and English; and educational institutions. It is impossible to mention all the contributors by name, but as all members of the British Association will see, they have done an excellent job.

The population of the city of Cardiff is now 253,000. Two million people live within a radius of thirty miles. Yet in 1801 Cardiff was a provincial market town with a population of only 1,870. As Prof. Brinley Thomas points out in the section on "The Growth of Population", Cardiff is there because of the Industrial Revolution; in particular, because of steam coal. In the early years of the Industrial Revolution the great centre in South Wales was Merthyr Tydfil, which in 1841 had a population of 35,000—three times that of Cardiff. But in 1841 the Taff Vale Railway, between Merthyr Tydfil and Cardiff was opened. There were soon extensions to the Aberdare Valley and the two Rhondda Valleys. Then Cardiff came into its own, for it is the natural outlet for the steam coalfields of South Wales. It soon developed the largest coal-exportation trade in the world.

The peak of the coal trade was just before the First World War. The population in 1911 was nine times the 1861 figure, and coal exports at nearly ten million tons had increased fourteen-fold in the same period. But although the peak came around 1911, the decline set in somewhat earlier, when because of inadequate port facilities in Cardiff, a large proportion of the coal trade was diverted to the nearby port of Barry. Barry's growth was even more sensational than that of Cardiff—from 494 in 1881 to 33,763 thirty years later. In common with other rapidly expanding towns, Cardiff at this time had a large migrant population. In 1911 only half the inhabitants had been born there.

But the growth of Cardiff is inseparable from the growth of the region, and the key to the region is coal. Coal has been worked in Glamorgan for hundreds of years, but until the eighteenth century it was on a small scale, chiefly at outcrops. Some was shipped across the Bristol Channel to Devon and Somerset.

The Industrial Revolution in South Wales started in the region of Merthyr Tydfil. In 1759 a partnership of nine people leased mineral rights in the area and started to build furnaces for smelting iron. One of them was Isaac Wilkinson, who introduced the process of coking coal for smelting iron in place of charcoal. The manager of the enterprise was John Guest, and he and Richard Crawshay, who later obtained control of a neighbouring area, founded the two great families of South Wales ironmasters—the Guests and the Crawshays.

The ironmasters were responsible for the building of the Glamorganshire Canal, from Merthyr Tydfil to Cardiff, and this Canal was the most important factor in the development of Cardiff up to 1840. Before that date not much importance had been attached to the exportation of coal, but in the 1840's, especially after a market was found for it in France, the steam coal from the Aberdare and the Rhondda Valleys began to dominate the region instead of iron. Pithead gears appeared up and down the pastoral valleys, and people moved in. By the beginning of the present century, the population of the Rhondda alone was more than 112,000. The tremendous demand for coal during the second half of the nineteenth century brought prosperity to the region, and led to the growth of the outlet port of Cardiff and later to the new port of Barry.

Coal may have become dominant in the mid-nineteenth century, but there were still plenty of ironworks. However, the development of steel technology in the 'sixties led to the closure of many of the smaller works and the growing dependence on imported ore led to re-siting closer to the sea or tidal estuaries.

The whole economy of the Cardiff region in the first part of the present century turned on coal, iron and steel, which is why the region was so hard hit by the depression in the 'thirties. World markets were contracting, and oil was a growing competition to coal. The result was mass unemployment and the hunger marches. Many left the region for the more prosperous Midlands and London. Between 1921 and 1931 there was a net loss of 230,000 people. The tide began to turn in 1935 when Richard Thomas and Co. bought the old steel works in Ebbw Vale and built there a new strip mill for the production of tin-plate. A trading estate was established, as part of a policy of diversification, and attracted a good many industrialists. By the end of the Second World War it was employing 17,000. By July 1955 unemployment in the region had fallen to 13,400—a peace-time record.

Coal and steel are still major industries in South Wales—the region produces 26 per cent of Britain's steel and has some of the largest and most modern works in Europe; but there are now many other industrial activities as well—aluminium, electrical engineering, synthetic fibres, for example.

The history, as opposed to the prehistory, of South Wales begins with the Roman conquest. The Romans made contact with the local tribe, the Silures, in A.D. 47 and fighting continued for thirty years or so. As usual, the Romans built forts and roads to facilitate the policing of the region. The remains of a typical fort is the Gaer, near Brecon. It comprised at first a rectangle of about eight acres with defensive earthen walls and ditches. Stone walls and gate-houses were added during the second century A.D. Towns grew up around the forts; for example, at Caerwent, where there was a regular street lay-out, public buildings, baths, houses and shops. Part of the defensive wall there still stands, 17 ft. high. At Caerleon, which became an important base about A.D. 75, there are also the remains of an amphitheatre in good condition.

From the departure of the Romans in the late fourth century to the Norman Conquest the history of the region is obscure, but during that time Christianity was introduced and the kingdom of Morgannwg established.

It was Morgannwg that opposed the Normans, under Robert fitz Hamon, Lord of Gloucester, during 1090–93, and he built a moated fort on the site that was later to be Cardiff. Fitz Hamon established feudal manors all over the plain close to the sea, but the mountains were left to the native Welsh.

Throughout the twelfth and thirteenth centuries Glamorgan was the scene of prolonged squabbles and wars, in which the Clare family and Llewellyns were greatly involved. The Clare family gradually gained control of the whole country but they lost it in 1314, and until the Act of Union under Henry VIII it was a pattern of mistake by the various Earls and their officials and rebellion by the Welsh. The new shire of Glamorgan, created by Henry VIII, had Cardiff as its county town.

To-day, Cardiff is the capital of Wales and has one of the finest civic centres in Britain. Adjoining the civic centre is the castle in 400 acres of parkland which was presented to the city in 1947 by the Marquess of Bute. Cardiff is still a major port for South Wales, and the dock area is an important part of the city. The notorious Tiger Bay is no longer what it was, and a recent film with that name was much criticized as not presenting a true picture of the city. Llandaff, a suburb of Cardiff, has been a religious centre for more than 2,000 years, and its fine cathedral dates from the twelfth century. It has been restored many times, and the most recent restoration after bomb damage in the Second World War includes the great choir arch bearing the Epstein "Majestas"—a figure of Christ in aluminium.

The Cardiff region has a remarkable variety of landscape in a small area. To the north is the South Wales Coalfield with its characteristic densely populated valleys—Rhondda, Cynon, Taff, etc.—reaching up into the moorland. Unlike the Midlands and South Lancashire, no one in the South Wales conurbation is far from open country. Farther to the north are the gaunt bare Brecon Beacons, nearly 3,000 ft. high. The steep northern scarp of the Brecon Beacons commands the valley of the Usk, in which the market town of Brecon lies, and to the east are the Black Mountains, less broken up, and more of a natural barrier than the Beacons. The Beacons, Fforest Fawr, the Black Mountains and the Usk Valley form the Brecon Beacons National Park.

To the north-west of Cardiff are the valleys of the Wye and the Monmow—a region rich in medieval buildings. There are Chepstow Castle on its limestone cliff, overlooking the Wye, the great Cistercian abbey of Tintern dating from the thirteenth century, and the bridge over the Monmow at Monmouth—the only one in the country with a two-storey fortified gate-house. Closer to the sea, the land is flatter and intensively farmed. The lower Usk Valley is one of the best cattle-fattening areas in Wales.

All in all, the Cardiff region, besides fine scenery, provides things of interest to all sections of the British Association. For the physicists there is the Department of Physics at the University and the Post Office Radio Research Laboratory. For the chemists, works of Pilkington Bros., Imperial Chemical Industries, Ltd., and Monsanto. For the geologists, there is the South Wales Coalfield; and for the zoologists, the coast, dunes, caves and mountain lakes. No section is short of interesting excursions.

## BRITISH ASSOCIATION PRESIDENT FOR 1961: SIR WILFRID LE GROS CLARK, F.R.S.

SIR WILFRID LE GROS CLARK, Dr. Lee's professor of anatomy in the University of Oxford since 1934, and Fellow of Hertford College, has been elected president of the British Association for the Advancement of Science for 1961. That year, the annual meeting will be held in Norwich.

Sir Wilfrid has achieved world fame as a human anatomist with special reference to palæontology and anthropology. Moreover, recognizing that the scientist should be interested not only in the science of discovery but also in scientific exposition and teaching, he has played a major part in the re-orientation of human anatomy as an academic discipline. This is exemplified by the organization of the new Department of Human Anatomy which was opened in Oxford last year (*Nature*, **183**, 1572; 1959).

Sir Wilfrid is also director of the Medical Research Council Unit for Research on Climatic and Working Efficiency and a member of the Royal Naval Personnel Research Committee. His earliest years of professional work were spent in medicine. During 1920–23 he was principal medical officer of Sarawak, and later he was professor of anatomy in St. Bartholomew's Hospital Medical College (1927–29), followed by St. Thomas's Hospital Medical School until 1934, when he transferred to Oxford.

Such is the high esteem in which his work is held that Sir Wilfrid has given numerous special lectures at home and abroad, and he has been the recipient of several medals and honorary degrees.

(*Continued from page* 836)

together with mitochondrial counts revealed a number of important modifications occurring after feeding 3′-methyl-dimethylamino-azobenzene. When 2′-methyl-dimethylamino-azobenzene was substituted for the former dye, the changes were quite different in the early part of the experiment, but approached those observed with 3′-methyl-dimethylamino-azobenzene at later stages. Allard also described a number of electron-microscope observations made on pre-cancerous liver. Particularly interesting were some images suggestive of mitochondrial division and others indicating the appearance of small granules closely associated with ergastoplasmic membranes.

Some problems of mitochondrial regulation were discussed by F. Lynen (Munich) and by J. D. Judah (Philadelphia). Lynen examined in detail the theory, proposed a number of years ago by himself and by M. Johnson, to account for the Pasteur effect in yeast. The mainspring of this theory is that glycolysis and oxidative phosphorylation compete for the limiting amounts of inorganic phosphate and adenosine diphosphate available in the cell. Thus, glycolysis is depressed aerobically and enhanced by anaerobiosis or by inhibition of aerobic phosphorylation. While this interpretation is supported by the results of phosphate analyses, it cannot explain the decreased aerobic utilization of glucose. To account for the latter phenomenon, Lynen has suggested that the adenosine triphosphate, formed aerobically in the mitochondria, may not be as readily available to the phosphokinases of the glycolytic system as the adenosine triphosphate formed in fermentation. Investigations aimed at verifying this possibility have confirmed the existence of an adenosine triphosphate shuttle between the particulate and the non-particulate phases of the cells, but have also revealed that phospho-fructokinase appears to be inhibited preferentially to hexokinase in aerobiosis. At present, there is no satisfactory explanation for this finding. In the discussion which followed this interesting paper, the possible organization of the ground plasm was brought up for consideration by several speakers.

J. D. Judah described a series of recent investigations carried out in relation with the finding that several anti-histamine drugs act as powerful protectors against experimental liver injury. It was observed that these drugs inhibit the swelling of isolated mitochondria, as determined by a variety of conditions, and that they also inhibit the reversal of this phenomenon under the influence of adenosine triphosphate. In addition, anti-histamines were found to have no effect on respiration or on oxidative phosphorylation, but to inhibit the transfer of phosphate from adenosine triphosphate to phosphoprotein. When added to liver slices, previously incubated anaerobically, the drugs prevented the extrusion of water and restoration of the level of phosphoprotein which normally occur when oxygen is allowed to enter into the system. Judah put forward the hypothesis that the reversible changes in the water content of the mitochondria may be determined by changes in their content of phosphoproteins and that anti-histamines may prevent both types of changes by inhibiting a reversible protein phosphokinase.

In the general discussion which concluded the meeting, the necessity for a closer co-operation between electron-microscopists, histochemists and biochemists was stressed. It was also pointed out that further progress in our knowledge of the organization of the cell will be greatly dependent on the development, in all three fields, of new methods of greater accuracy and increased power of resolution.

C. DE DUVE

# THE PHYSICAL SOCIETY

THE principal contents of the 1959 Year Book of the Physical Society (pp. vi+124. London: Physical Society, 1959. 12*s*. 6*d*.), the fifth in the annual series, consists of the presidential address, entitled "Recent Trends in the Theory of the Ionosphere", which was delivered by J. A. Ratcliffe on May 21, 1959, following the annual general meeting of the Society, and the texts of the lectures and addresses given by the recipients of the various medals and prizes of the Society. Details are also given of the discourses delivered at the fifty-third Physical Society exhibition of scientific instruments and apparatus; the proceedings of the meetings of the Society during the period September 1958–June 1959; and the report of the Council of the Society for 1958. In addition, there are obituary notices of ten Fellows, including Sir Alfred Egerton, Prof. E. O. Lawrence, Prof. O. W. Richardson and F. Twyman.

In his presidential address, Mr. Ratcliffe gave a survey of recent ideas concerning the formation of the upper part of the ionosphere, known as the *F* layer. From measurements of the atmospheric density at great heights and computations of the electron distributions, it would appear that the layer is produced by the absorption of a solar ionizing radiation in atomic oxygen, which is distributed through the atmosphere as it would be if mixing were nearly complete up to heights of about 400 km. at least. When the radiation is incident normally, the absorption coefficient of the radiation is such that electrons are produced most rapidly at a height of about 180 km. Small alterations in the amount of mixing can produce marked changes in the electron distribution, and changes of this kind could be the cause of the observed winter anomaly in middle latitudes.

The forty-third Guthrie lecture, which was delivered by Sir Harrie Massey on April 8 at Oxford, was entitled "Collisions", and was confined to a discussion of a selected number of atomic collision phenomena including the elastic and inelastic collisions of electrons and of positrons with atoms, recombination and charge transfer processes in the upper atmosphere, and the dissociation of molecular ions by impact with gas atoms. The subject of the fifteenth Charles Vernon Boys Prize address given by Dr. D. West, of the United Kingdom

Atomic Energy Authority, Harwell, was a description of the method of observing $\pi$-mesonic X-rays. The work discussed was carried out on the Liverpool synchrocyclotron during 1952–56 and the main item of measuring equipment was a Hutchinson–Scarrott type kicksorter. It is most interesting, therefore, to find that the thirty-sixth Duddell Medal addresses, which follow Dr. West's article, were delivered by G. G. Scarrott on the application of computer techniques to nuclear physics instruments and by G. W. Hutchinson on 'memories' for nuclear physics.

In 1959 it was the turn of the Physical Society to arrange for the delivery of the Parsons Memorial Lecture, and Dr. C. R. Burch was invited to be the lecturer on October 22, 1959, at the Science Museum, London. He chose to speak about aspheric imaging systems and described the work in this field carried out by the University of Bristol's Optical Group during the past twenty years. Under Dr. Burch's inspiring influence, his devoted band of research workers, all of whom he proudly mentions by name and with affection, have made, many with their own hands, optical instruments of new and advanced design. Advanced testing methods, aspheric reflecting microscope design and manufacture, meniscus-Schmidt camera design and manufacture, cone-cylinder and screw interferometers, and several applications particularly in the biological field of these instruments are all touched on in Dr. Burch's lecture.

The subject of the twentieth Thomas Young Oration, given by Prof. R. W. Ditchburn on November 12, 1959, was also of an optical nature. He dealt with problems of visual discrimination, and described various methods of recording eye-movements and the analysis of involuntary movements. Eye-movements, both voluntary and involuntary, are of importance in contrast discrimination, and from the study of the discrimination of hue, it appears that in some conditions, normal subjects give reports usually associated with defective colour vision. The question as to how far the results obtained on the living eye are related to theories of retinal action is discussed with reference to electro-physiological measurements of impulses in optic nerve fibre of animals.

The lectures and addresses were intended for a very wide audience, and are extremely well and clearly written. They deal with specialist subjects, but their contents do not require specialist knowledge to understand them. The Year Book is a worthy addition to all science libraries.

## THE COLONIAL DEVELOPMENT CORPORATION

THE annual report and statement of accounts of the Colonial Development Corporation for the year ended December 31, 1959*, the first to appear over Sir Nutcombe Hume's signature as chairman, follows the general style of Lord Reith's recent reports. Eighty-eight continuing projects are reported, as against seventy-seven the previous year, including fifteen new projects totalling £13,184,000, of which four have been removed from the list, and £4,046,000 further investment in existing projects was approved. Of the continuing projects, representing £90 million, of which £60 million has been spent, 45·2 per cent were concerned with utilities, 43·1 per cent with primary production and processing, and 11·7 per cent with commerce and industry, the corresponding figures for 1958 being 46·9, 40·8 and 12·3 per cent, respectively. No capital has yet been raised from outside sources, nor has any attempt been made to do so. Although the Corporation is now well established and its revenue is increasing, its present capital structure is unsuited to raising outside capital except with the Government's guarantee, but if the recommendations of the Sinclair Committee are adopted it should be much easier to devise a form of capital which would find purchasers among private investors without such a guarantee. The Corporation, however, is nearing the end of the resources it can draw from the Government, and further capital may soon be needed if it is to go forward.

The report emphasizes the importance of the correct adjustment of the relation between the highly industrialized countries and the under-developed countries of the world; and in these territories, for which the United Kingdom Government is responsible, the Corporation is in a unique position to assist in finding a solution to this problem. Even when money and technical aid are available, the capacity to put them to the best use is often lacking, and the Corporation has now built up an organization staffed by experienced people and designed for this very purpose. Their fitness for the task is shown both by the success now being achieved by the Corporation and by the fact that commercial interests, which have been hesitant to participate in risk ventures in territories the political and economic future of which was uncertain, have been reassured when the Corporation has been ready to be associated with their investment.

To assist in securing the maximum use of the Corporation's experienced organization in Great Britain and abroad, the chairman is leading a mission of the general manager and all six regional controllers to Washington to discuss the possibilities of the Corporation working for the International Bank, the International Finance Corporation and the Development Loan Fund. To-day the Corporation is well equipped to make contact with and examine new projects anywhere in the present or former dependent territories, to negotiate or assist in negotiating the terms of investment, to arrange for the management of the project and to watch over its progress. Almost all its capital of £130 million is now committed, and the value of products by direct projects and associated companies in 1959 amounted to about £18 million, much of which contributed to the export trade of the countries concerned. The stimulation of other development caused by the Corporation's example and initiative is more difficult to assess, but the report cites as examples new housing enterprises and ideas due to the Malaya Borneo Building Society and housing schemes in Africa and the Caribbean, and new standards for large-scale agricultural enterprises in Borneo set by Borneo

* Colonial Development Corporation. Annual Report and Statement of Accounts for year to 31.12.59. Pp. v+77. (London: H.M. Stationery Office, 1960.) 5s. net.

Abace, Ltd., in introducing two new crops (cocoa and oil palms). The report also stresses the way in which opportunities are taken for partnership with private industry and association with local interests, and apart from stressing the importance of public relations and encouraging both at home and overseas a correct understanding of the Corporation's purpose and work, the report contains two interesting sections discussing various aspects of management and training schemes which merit separate consideration.

## ECHO-SOUNDING EXPERIMENTS IN THE BARENTS SEA

NEARLY all large fishing vessels carry echo-sounders for locating fish. A 'ping' of sound is sent down into the water, and any fish between the ship and the sea bed give echoes which can be detected. In the case of vessels trawling for cod, it is fish within a few fathoms of the sea bed which are of interest, and because of the short separation in time between the echoes from these and the much stronger echo from the sea bed, certain difficulties arise. These have to a large extent been overcome by displaying the echoes on a cathode-ray oscilloscope, arranged to present echoes from near the sea bed on an expanded scale.

A recent booklet contains five papers concerned with the use of such equipment*. They cover the identification and measurement of the echoes, the relationship of the number and size of echoes to the catch of fish, the measurement of the strength of echoes from individual fish, practical and theoretical work on the properties of the equipment, and its use for surveying the distribution of fish on the fishing grounds. Taken together, they form a comprehensive survey of the characteristics and use of the equipment considered primarily from a practical point of view.

One is particularly struck by the high correlation between the count of echo signals, that is, the sum of the strengths of each echo during a trawling run, corrected for depth, and the number of fish caught. The correlation coefficients are in the region of 0·9, in spite of the necessarily rather crude methods of echo measurement.

In the past, much of the information required for systematic design of echo-sounders for fish detection has not been available. Design has been based largely on the properties of previous models known to give reasonably satisfactory results, followed by sea trials and alterations as required. The third paper describes an attempt to obtain some of the necessary basic data. The echo strength given by (dead) cod of different lengths has been measured and compared with the echo given by a standard target, so that the target strength of the cod is known in absolute units. The water-borne noise has been measured as a function of ship-speed and water-depth (though unfortunately only in terms of received voltage without the sensitivity of the receiver being known). The information about the target strength of cod is of universal application, and that about the water-borne noise allows the prediction of the performance of this particular sounder over a wide range of conditions.

The checking of the performance of equipment under working conditions is highly desirable, and helps to give one confidence in both the equipment and one's methods. The first part of the fourth paper describes checks of the beam pattern and of the variation of echo-strength with depth. Such checks have been made on many other acoustic devices, and since in the present case they also agree with theoretical expectations within experimental accuracy, the fifteen pages devoted to this work seem excessive.

In conclusion, these papers describe a great deal of careful work, mostly 'in the field', and form a very valuable contribution to the subject.

M. J. TUCKER

* Ministry of Agriculture, Fisheries and Food. Fishery Investigations, Series II, **22**, No. 9: Echo Sounding Experiments in the Barents Sea. By I. D. Richardson, D. H. Cushing, F. R. Harden Jones, R. J. H. Beverton, and R. W. Blacker. Pp. vi+57. (London: H.M. Stationery Office, 1959.) 20*s*. net.

## ORIGIN OF TEKTITES

By PROF. H. C. UREY, For.Mem.R.S.
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LAST January, Dr. G. Baker[1] criticized in considerable detail my suggestion[2] that comet heads colliding with the Earth heated the surface to the melting point and spread small fragments of glassy objects to great distances and that these objects are tektites. I believe these objects have compositions which are not greatly different from some of the more acid terrestrial rocks, but that no source of sufficiently high temperatures to melt these materials is known to be present on the Earth's surface or somewhat below the surface. My communication was written to suggest a possible source of high temperatures. I really thought everyone who had worked on this problem would be pleased to consider a mechanism by which terrestrial material could be melted and scattered to great distances even though it did not necessarily answer all questions. This was certainly not true. I have thought over Dr. Baker's very thoughtful criticisms and would like to make a brief reply.

Dr. Baker is quite right about tektites not being spaced some 50 million years apart in age, but Prof. Z. Kopal very soon pointed out to me that cometary collisions with the Earth were probably ten or more times as frequent as I had assumed. I have not troubled to correct this incorrect estimate, for it was very uncertain in any event. We probably have only the most approximate ideas in regard to the numbers of non-luminous comet heads moving in the solar system; and comet heads must certainly collide

with the Earth from time to time and should produce some effects which we could look for, and they should produce an effect of sufficient magnitude possibly to melt bits of glassy materials.

Also, Dr. Baker is right about the orientation of tektites during flight through gas. The stable position is motion through the gas with a maximum surface exposed in the direction of flight.

Dr. Baker accepts the conclusion that a swarm of objects of very considerable mass is required if such a swarm is to remain as an entity in the field of the Sun, and he tries to account for a large loss of this mass by abrasion during flight through the air, erosion after arrival at the Earth, and destruction by birds and men. If we postulate very many small masses, say, of millimetre sizes, then it is difficult to answer the first objection. But 100 gm. per cm.$^2$ over an area of 5 million km.$^2$ is $5 \times 10^{12}$ tons, and hence we must assume a very large fraction of very fine material in order to account for its destruction in this way. The total energy of this mass of material, using his area of $5 \times 10^5$ km.$^2$ ($2 \times 10^5$ square miles) and a thickness of 100 gm./cm.$^2$ and a velocity of 20 km. per sec., is $10^{31}$ ergs. This is equivalent to about $10^{10}$ ordinary Second World War atom bombs, or 2,000 per km.$^2$. The energy per cm.$^2$ is $2 \times 10^{14}$ ergs. The heat capacity of the atmosphere is about $10^{10}$ ergs per cm.$^2$ and thus very high temperatures would be produced. Possibly such energetic processes occurred over southern Australia some 5,000 years ago, but also some evidence of it might remain. Possibly my scepticism based on inadequate knowledge is not unjustified.

The etching experiments with 4 per cent hydrogen fluoride do not seem to be very appropriate as a test of chemical erosion, since this reagent is used to dissolve rocks of all kinds and is known to be a very effective chemical for such purposes, since it converts silicon dioxide to gaseous silicon fluoride. Carbon dioxide and water is the usual erosion acid in Nature and it is much milder in its effects. But tektites have persisted on the Earth since the Eocene apparently, and during this long period should have been exposed to all the types of erosion that occur in Nature and they still have survived. Also tektites are abundant in the Philippines and other tropical humid regions and are fairly well preserved. The erosion of a layer of tektites of 100 gm./cm.$^2$ from the southern Australian continent in 5,000 years does not seem probable to me, especially in view of the fact that, as Dr. Baker emphasizes, some of these objects are beautifully preserved. In fact, most of those that I have seen are so preserved. Could this vast amount of material of a very resistant kind have disappeared so completely in a short period of time? It seems improbable to me that both this great and complete destruction of so much material and the perfect preservation of specific samples under essentially similar conditions could have occurred.

Again, birds and men cannot dispose of such quantities of material, or even a small fraction of it, in so short a time, and it would seem likely that tektites would have become distributed over the whole of Australia instead of being limited to the southern part if such agents moved any important amounts of these materials.

But my mention of the swarm of objects and its elimination was very brief. If we are seriously to assume the existence of such a massive swarm, we must consider whether it would not have accumulated due to its own gravitational forces into a more compact object and hence have arrived at the Earth as such. In this case it approximates to the cometary model, or to a large meteorite model, and then we are back to scattering materials over vast areas. However, with these models it is unnecessary to assume a layer of 100 gm./cm.$^{-2}$, since this estimate depended on the extended cloud model and its stability in the Sun's field; also the energy dissipated, while very great, would be more limited in area and might well initiate volcanic or flooding processes, for example, which would obscure the location of the collision site.

But we are learning more about these objects. It is now found[3] that they do not contain aluminium-26, which was previously reported. There is no evidence that they have been exposed to cosmic rays. If they came from space in a swarm, the time in space was very brief. They may have come as a large compact object or they may have come from the Earth. Also, the potassium-40/argon-40 ages have been determined[4], and it is found that these ages for all tektites of south-east Asia and Australia are the same within the limits of error, namely, 610,000 $\pm$ $\sim$ 50,000 years. The ages from geological studies that Dr. Baker mentions might be in agreement with this age for all these objects with the exception of the age of the australites, which he estimates as 5,000 years or "definitely Holocene". The potassium-40/argon-40 ages are calculated assuming that complete degassing took place at some time in the past. The consistency of the ages supports this, though one could wish that the variations, either real or due to observational errors, were less. If the age of 5,000 years given by Dr. Baker and that of 610,000 years given by the potassium-40/argon-40 ratio for the australites are correct, a degassing occurred 610,000 years ago, but delivery to Australia occurred much later. One wonders how and where that heating process occurred and where the objects were kept in the refrigerator free from cosmic rays since that time? I really am most reluctant to assume that the carefully considered age of the australites is wrong, but if they arrived 610,000 years ago it would greatly simplify our attempts to arrive at a satisfactory model. If the differences in geological age estimates and the potassium-40/argon-40 ages for all these groups of tektites are real, then similar questions in regard to the heating and cooling histories can be raised in regard to all of them.

If the agreement in potassium-40/argon-40 ages is significant—and I believe it is—a very great and extensive process must have produced these objects and we must all think again about the entire problem.

Did they come from the Moon? Could a collision of an object with the Moon splash them off in such a closely related pattern that they would all fall in these close patterns[5]? But would all such collisions produce such closely controlled conditions, or would they miss the Earth occasionally or, in fact, usually, and thus on a second, third or the $n$th pass fall all over the Earth? My answer is that they most probably would be very widely, and in fact uniformly, scattered over the Earth[6].

However, it has always been a puzzle to me that terrestrial surface materials containing appreciable water should melt into objects having so little water. Why did they not melt into pumice? But I have only tried to suggest a source of heat for melting this material and scattering it over great distances. It seems more reasonable to try to fashion some hypothetical process to produce them from known terres-

trial materials, which they resemble in many ways, than to assume that they come from other places that we know so little about. Must we fashion another planet to produce their chemical composition, and then if we cannot find ways to melt these materials on Earth, why do we think they could be melted elsewhere ? If geologists will find a volcanic process which will produce these objects from appropriate terrestrial materials, such a solution would be the most satisfactory of any that I could imagine. (Mr. Paul Lowman mentioned this possibility to me in conversation.) But a volcanic process distributing material in limited regions over south-east Asia and Australia within a circle of 8,000 km. diameter would be most remarkable.

On the other hand, cometary collisions should occur occasionally, they should be very energetic, and their volatile constituents should supply a mechanism for propelling materials out of the atmosphere and to great distances, and the agreement in the potassium-40/argon-40 ages would be understandable. It could have been a single collision near the centre of this area, instead of multiple but nearly simultaneous ones as suggested previously.

It is nearly three years since my suggestion on the cometary origin of tektites appeared in *Nature*. I wish to thank Dr. Baker for raising the problem for public discussion and am only sorry that he did not do so earlier. Progress in resolving differences of this kind can be made most expeditiously by a public discussion of this kind in which all interested parties, including the one whose work is criticized, may know what doubts are being entertained.


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[2] Urey, H. C., *Proc. U.S. Nat. Acad. Sci.*, **41**, 27 (1955); *Nature*, **179**, 556 (1957).
[3] Anders, E., *Geochim. Cosmochim. Acta*, **19**, 53 (1960).
[4] Gentner, W., and Zähringer, J., *Zeit. f. Naturforsch.*, **14**, A, 676 (1959).
[5] Varsovsky, C. M., *Nature*, **181**, 172 (1958).
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# ISOTOPIC COMPOSITION AND TEMPERATURE OF FORMATION OF ANTARCTIC SNOWS


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In an earlier communication[1], variations in the isotopic composition of the oxygen in falls of snow collected during 1958 at the Belgian Antarctic Base (King Baudouin Base, 70° 26′ S., 24° 19′ E.) were shown.

We intend, here, to present the variations in the isotopic composition of the hydrogen contained in the same samples.

The analysis of the aerological radio soundings carried out at the King Baudouin Base in the course of the International Geophysical Year[2] has enabled us to estimate the temperature range in the cloud corresponding to each snow-fall. This is, to the best of our knowledge, the first attempt carried out with the view of establishing a direct correlation between the isotopic composition of a snow-fall and its temperature of formation. The interesting results obtained in this field up to the present[4,5] originate from average samples representing accumulations over severa months, or even years.

## Variations of the Deuterium : Hydrogen Ratio

The ratio deuterium : hydrogen has been measured at the U.S. Geological Survey, Washington. The mass-spectrometric methods used have already been described[6].

Fig. 1 shows the variations of the deuterium : hydrogen ratio in the course of 1958. Each point represents an individual sample. The composition of the hydrogen is expressed as percentage variation of the deuterium : hydrogen ratio with respect to a conventional standard (standard mean ocean water). The variations of the deuterium : hydrogen ratio present the same characteristics as those of the oxygen-18 : oxygen-16 ratio previously discussed[1]; but their amplitude is 10 times larger[3]. Thus, summer snows are, in the average, 10 per cent richer in deuterium than winter snows. The maximum relative variation in the deuterium content is 20 per cent.

Fig. 2 shows the variations of $\partial$ (oxygen-18 : oxygen-16 ‰) with respect to $\Delta$ (deuterium : hydrogen per cent). As a first approximation, all the points are grouped about a straight line of equation : $\partial = 0{\cdot}8\,\Delta + 1{\cdot}8$. It appears that some points corresponding to August and September, that is, the end of winter, form a separate group.

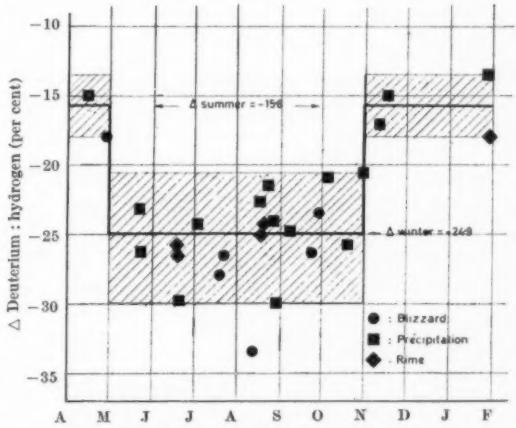


Fig. 1. Variations of deuterium : hydrogen ratio in snow samples during the course of the year (1958)

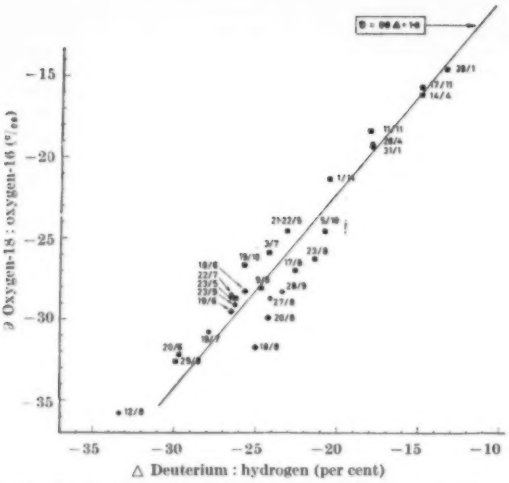


Fig. 2. Deuterium : hydrogen ratio compared with oxygen-18 : oxygen-16 ratio in the same sample. Same symbols as in Fig. 1. The date of collection is given for each sample. Oxygen isotopes data from Gonfiantini *et al.* (ref. 1)

## Isotopic Composition and Temperature of Formation

In order to estimate the range of the temperature of formation of every fall of snow, we have noted from the radiosonde data the temperature at the base and at the top of the cloud at the moment of precipitation. This temperature is well defined in the fortunately frequent case of thin stratiform clouds with no higher cloud sheets. In the case of rime deposits, the temperature at a height of 1 metre above ground was taken. Drift-snow samples were excluded.

Table 1 shows the information obtained from the aerological soundings.

Fig. 3 shows the isotopic composition of the oxygen in each fall, with respect to the temperature-range in the corresponding cloud sheet. The straight line corresponding to the mean temperature of the cloud has been traced. There is seen to be a remarkable correlation between $\partial$ oxygen-18 and the temperature of formation of the precipitation, $T$.

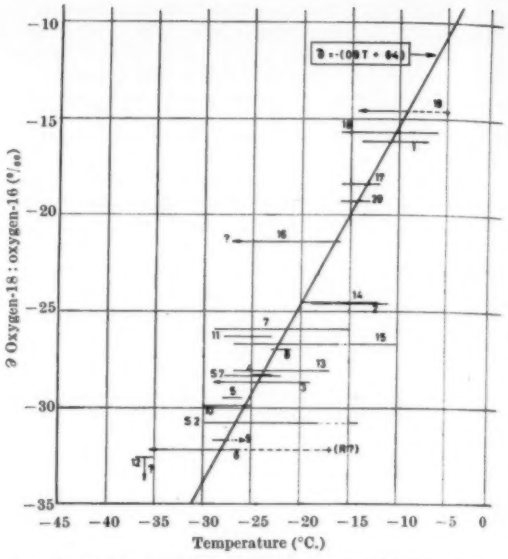


Fig. 3. Isotopic composition of oxygen in snow falls with respect to the temperature in the corresponding cloud sheet. Sample numbers refer to Table 1

The equation connecting $\partial$ and $T$ is :

$$\partial(\text{oxygen-18}) = -(0{\cdot}9T + 6{\cdot}4)$$

An equally precise correlation has been found to exist between $\Delta$ (deuterium) and $T$, and is represented by the equation :

$$\Delta\ (\text{deuterium}) = -(0{\cdot}8T + 8)$$

The isotopic compositions $\partial$ and $\Delta$ essentially depend on the temperature of formation, and appear, at first sight, to be independent of any other condition such as the cloud height or the type of precipitation.

The very marked seasonal effect, and the very rapid transition from the 'isotopic winter' to the 'isotopic summer' (Fig. 1), may be clearly interpreted by referring to Fig. 4, which presents the mean monthly temperature of the air with respect to its height, in the atmosphere above King Baudouin Base. The known polar climatic characteristics very clearly

Table 1

| Sample No. | Date | Ground temperature (°C.) | Temperature in the cloud | | ∂ Oxygen-18 (‰)* | Δ D/H (per cent) | Type and mean height of cloud |
|---|---|---|---|---|---|---|---|
| | | | Min. | Max. | | | |
| *P* 1 | 14/4 | − 7 | − 7 | −14 | −16·2 | −14·9 | st. 800 m. |
| *P* 2 | 21/5 | − 9 | −11 | −19 | −24·6 | −23·1 | sc. 1,400 m. |
| *P* 3 | 23/5 | − 8 | −19 | ? | −28·7 | −26·2 | as. 3,000 m. |
| *R* 4 | 18/6 | −24 | −24 | −24 | −28·3 | −25·7 | (rime) 0 |
| *R* 5 | 19/6 | −23 | −25 | −27 | −29·5 | −26·5 | (rime) 0 |
| *P* 6 | 20/6 | −17 | −22 | −29 | −32·2 | −29·7 | sc. 1,750 m. |
| *P* 7 | 3/7 | −10 | −15 | −29 | −25·9 | −24·2 | as. 2,800 m. |
| *S* 7 | 19/7 | −18 | −19 | −30 | −30·8 | −27·9 | ns. 2,300 m. |
| *P* 8 | 17/8 | −21 | −22 | −22 | −27·0 | −22·6 | sc. 1,300 m. |
| *R* 9 | 18/8 | −28 | −28 | −28 | −31·7 | −25·0 | (rime) 0 |
| *R* 10 | 20/8 | −27 | −25 | −30 | −29·9 | −24·2 | (rime) 0 |
| *P* 11 | 23/8 | −24 | −23 | −28 | −26·3 | −21·4 | sc. 1,100 m. |
| *P* 12 | 29/8 | −31 | −35 | −37 | −32·6 | −29·9 | ac. 2,550 m. |
| *P* 13 | 8/9 | −17 | −15 | −27 | −28·1 | −24·7 | sc. 1,800 m. |
| *P* 14 | 5/10 | −12 | −12 | −20 | −24·6 | −20·8 | st. 1,000 m. |
| *P* 15 | 19/10 | − 6 | −16 | −27 | −26·7 | −25·7 | ac. 3,700 m. |
| *P* 16 | 1/11 | − 7 | −16 | ? | −21·4 | −20·5 | ac. 2,100 m. |
| *P* 17 | 11/11 | −10 | −13 | −16 | −18·4 | −17·3 | st. 1,200 m. |
| *P* 18 | 17/11 | − 5 | − 6 | −16 | −15·7 | −15·7 | sc. 1,200 m. |
| *P* 19 | 28/1 | − 3 | −11 | ? | −14·6 | −13·4 | |
| *R* 20 | 31/1 | −13 | −13 | −16 | −19·3 | −17·9 | (rime) 0 |

* Oxygen isotopes from Gonfiantini (ref. 1).

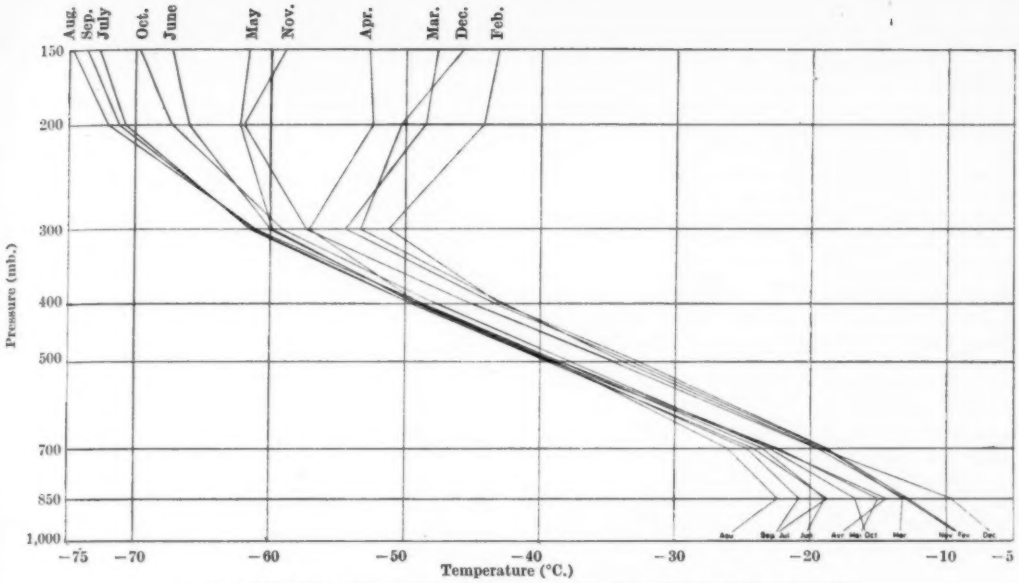


Fig. 4. Monthly mean temperatures from upper-air soundings at King Baudouin Base—1958

discussed in a recent article by Wexler[7] are found here. It is clear that the temperatures of the middle troposphere in which the precipitating clouds form are closely grouped about two mean values, and that these temperatures pass from the mean summer to the mean winter values in two abrupt jumps—between March and April, and between October and November. These two periods correspond very well to the abrupt variations in the isotopic composition of the precipitation (Fig. 1). As this behaviour of the tropospheric temperature is characteristic of the antarctic climate[7], it is to be hoped that the type of isotopic variations observed in 1958 follows a rule which will apply to other years.

On Fig. 4 is to be noted the wide dispersion of the ground temperatures, due mainly to the winter ground-inversion. This shows that ground temperature is not the best parameter to be used in work of this type.

In conclusion, the ratios oxygen-18 : oxygen-16 and deuterium : hydrogen in the snow-falls are seen to vary in a very similar pattern. These two parameters represent a veritable thermometer of the temperature of the middle troposphere, where the clouds causing the precipitation are formed. A variation of 1 deg. C. corresponds to a relative variation of about 1 ‰ in the ratio oxygen-18 : oxygen-16, and 0·8 per cent in the ratio deuterium : hydrogen—both values are well above the experimental errors of measurement.

The recent work of Dansgaard *et al.*[5] carried out on Greenland ice of known ages confirms that the isotopic composition of snow is conserved for at least several hundreds of years, even through compaction and transformation into ice. A very important application of these results would be a study of the recent climatic variations of the antarctic continent.

A full account of this work will be published elsewhere.

We wish to thank Dr. H. Wexler (U.S. Weather Bureau), Dr. W. Dansgaard (University of Copenhagen), Drs. E. Roth and G. Nief (C.E.N., Saclay) and Prof. E. Tongiorgi (University of Pisa) for helpful discussions.

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# VALENCE-BOND STRUCTURES: A NEW PROPOSAL

By Dr. J. W. LINNETT, F.R.S.*
Chemistry Department, University of California, Berkeley

IN the simple valence-bond treatment of molecules such as $CH_4$, two electrons having opposed spins are assigned to each bond. A similar feature applies to such molecules as $H_2O$ in which there are lone-pairs. It is assumed, in all these molecules, that there is a group of electrons of one spin and an *exactly* similar group of electrons of the other spin. For structures such as that of $C_6H_6$ or $CO_2$, which cannot be described adequately in such simple terms, the concept of resonance has been introduced, the structure being represented by a combination of two or more structures of the above kind. That is, each

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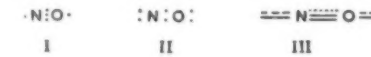
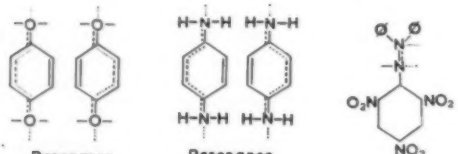
structure is made up of shared and lone pairs of electrons, and each structure has two identical sets of electrons, one being made up of electrons of spin $+\frac{1}{2}$ and the other of electrons of spin $-\frac{1}{2}$. It is the purpose of this communication to suggest some modifications of this approach, and, in particular, to propose a partial revision of our interpretation of the stability of such molecules as benzene and carbon dioxide, which is usually ascribed to resonance, and measured by resonance energy.

The modification that is proposed here was suggested by a consideration of the structure of the relatively stable 'radicals': nitric oxide, the *p*-benzosemiquinone negative ion, Wurster's blue ion, diphenyl-picryl-hydrazyl, etc. In nitric oxide, there are five valency-shell electrons of one spin and six of the other. The first form a grouping in the molecule, which is represented by (I) and the second by (II):



I II III

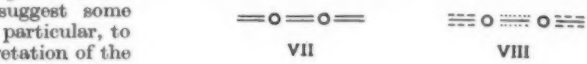
In both (I) and (II), there are four electrons (lone and shared) associated with each atom. So, if (I) and (II) are combined, the structure would be such that each atom possessed a shell of eight electrons made up of four of one spin and four of the other. Moreover, it is possible for each set of four to have a high probability of having a configuration which is nearly tetrahedral, though the two tetrahedra around each atom would not be superimposed. The combination of (I) and (II) may be represented fairly satisfactorily by (III), where —— signifies two electrons with opposed signs, - - - - one electron with one spin, and ····· one electron with the other spin[1]. On this basis the *p*-benzo-semiquinone negative ion, Wurster's blue ion and diphenyl-picryl-hydrazyl would be represented by (IV), (V) and (VI), along with other structures which are probably less important.




IV V VI

In all the above structures every carbon, nitrogen and oxygen atom has a shell of eight electrons, four of each spin. It is postulated that it is because such structures can occur and are important that the above substances show a high stability which may, otherwise, seem surprising. For example, if diphenyl-picryl-hydrazyl were to dimerize, there would be no net gain in the number of bonds, because the formation of the new bond would take place at the expense of the loss of the two half-bonds between the nitrogen atoms. The same is true for the semiquinone, as regards both polymerization and electron-transfer to produce the quinone and hydroquinone double negative ion. In (IV) and (V) above, it has been assumed that the structure is best described by a mixture of the two equivalent structures (resonance). This is required by the symmetry of the molecule.

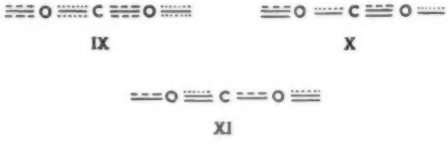
This concept can be applied much more widely, but consideration will be limited here to the molecules $O_2$, $CO_2$ and $C_6H_6$. Oxygen, with twelve valency-shell electrons in all, could be imagined as adopting one or other of the structures (VII) and (VIII).



VII VIII

In both, each atom has a shell of eight electrons, four of one spin and four of the other, and also for both there are four electrons involved in bonding. Which of these is going to be the ground-state? It is not surprising that (VIII) is, because, in this electron configuration, five electrons have the configuration ·O ⋮ O·, whereas the other seven have ⋮ O·O ⋮. As a result, the electrons, forming tetrahedral groupings, tend to be more widely separated on an average in (VIII) than in (VII). According to this approach, which is essentially an extension of the valence-bond method, it is just as easy to understand why the ground-state of $O_2$ is the triplet state, as it is on the method of molecular orbitals. The $^1\Delta$ and $^1\Sigma$ states of $O_2$ are 22·6 and 37·6 kcal. above the ground-state[2]. The latter resembles more closely the double bond in a polyatomic molecule (for example, ethylene) because the azimuthal positions of the electrons in the $\pi_g$ orbital are uncorrelated (by spin correlation) in the $^1\Delta$ state, whereas they tend to be at the same azimuthal angle in the $^1\Sigma$ state. Thus, the adoption of structure (VIII) would appear to lower the energy about 35–40 kcal. relative to (VII), if (VII) represents a double-bonded structure of the type that exists in ethylene.

Now, for $CO_2$, resonance involving the structures =O=C=O= ≡O—C≡O— and —O≡C—O≡ is usually supposed to occur. According to the present idea, there would be added:



IX X XI

Of these, (IX) is likely to be the most important because it reduces the magnitude of inter-electron repulsion energy more than do the others. In (IX) the two bonds are analogous to the bond in (VIII). On this basis, it is not surprising that $CO_2$ is 36 kcal. (ref. 3) more stable than would be expected for the structure =O=C=O=. Moreover, the stabilization is not ascribed entirely to resonance but to the reduction in the inter-electron repulsion in (IX) as compared with that to be expected in =O=C=O=. Of course, it will still be true that a better description of the structure of $CO_2$ would be provided by resonance between (IX), (X), (XI) and the three conventional electron-pair structures. However, what is being suggested here is that it seems possible that (IX) is an important structure, and probably the most important one.

In a similar manner, benzene would be written as

XII

and the stabilization energy of 37 kcal. relative to a Kekulé structure (ref. 3) would be interpreted as being due, in large part, to a reduction in the inter-electron repulsion energy in (XII) as compared with that in a Kekulé structure involving the conventional double-bonds. It is of the same order as that found in $O_3$ and $CO_2$, and it is therefore not unreasonable to suppose that analogous effects are important in all these molecules. Further, the most simple-minded approach to electron–electron repulsion surely indicates that configurations which have high probability according to (XII) must, in truth, have a considerable probability relative to those indicated by the Kekulé formulæ. Yet, resonance between the two Kekulé forms sets a low probability on such configurations which separate spatially all the six electrons of the 'aromatic sextet' but nevertheless locate all in bond regions.

These ideas can be extended to other aromatic systems, chemical reactions, other free radicals, certain molecular compounds, all other systems which are usually represented in terms of resonance, and complex ions; and these and other applications will be presented elsewhere. Here the account given has been qualitative, but wave-functions can be devised which correspond to the above structures and hence quantitative and semi-quantitative developments are possible. The method would be an extension of the valence-bond method. However, the wave functions could not be of the Heitler–London type but some modified or new form would have to be developed. This should not be difficult.

The proposal submitted here may be summarized in the following way. G. N. Lewis[4] stressed the importance of the electron octet. In all cases he treated it as made up of four pairs. It is suggested here that it is better to treat it as two groups of four electrons. When the two groups of four are similarly disposed, as they are in many molecules, the descriptions as four-pairs or two-quartets become identical. However, in other molecules and radicals, the employment of the two-quartets concept provides a satisfactory description, whereas the Lewis four-pairs does not. Therefore, it is proposed that the *octet* should not be treated primarily as four pairs but rather as a *double-quartet*.

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# CHROMOSOME PLOIDY AND RADIOSENSITIVITY OF TUMOURS

By LÁSZLÓ REVÉSZ and ULLA NORMAN

Institute for Tumour Biology, Karolinska Institutet Medical School, Stockholm

THE cell populations of animal and human neoplasms frequently show a considerable variation in chromosome number and deoxyribonucleic acid content[1,2]. It is not known whether there is any relationship between the chromosome number and the radiosensitivity of tumour cells. Work on the relationship between ploidy and sensitivity to radiation has been carried out on cells falling into the euploid series and derived from such biological objects as plants, fungi and arthropods[3]. If the effect of radiation on cell multiplication alone is considered, all reported observations indicate that radiosensitivity is greatest in the haploid cell and decreases more or less regularly with increasing ploidy. No direct extrapolations to neoplastic cells are permissible, however, since the predominant stem-line cell type is aneuploid in many tumours. The main stem-line number is frequently doubled, more or less exactly, in a smaller, second stem-line[1]. It cannot be predicted how a given aneuploid stem-line will react to radiation as compared to the doubled stem-line. Rearrangements occurring concurrently with, or after, duplication may, for example, render sensitive sites monosomic and make the cell more sensitive to radiation.

The problem was approached experimentally by determining the radiosensitivity of selected sub-lines of different ploidy derived from the same original tumour. In such material the findings can be interpreted with more confidence than would be the case when comparing independent tumour cell populations of different ploidy which, besides possible differences in radiosensitivity, may differ with regard to many, not necessarily relevant, other characteristics. An Ehrlich ascites tumour, designated *ELD*, also known under the synonym Landschütz sarcoma I or under the designation *LE* was used[4–6]. This tumour and its sub-lines were maintained in adult, heterozygous mice by intraperitoneal transfer of 0·1 ml. ascites diluted tenfold with sterile Ringer solution. During several periods of varying length, the cells were stored at −79° C. Chromosomes were counted on aceto-orcein squash preparations of material treated with colchicin[7]. More than 95 per cent of the *ELD* population is hyperdiploid with a modal chromosome number of 46. Cells with a doubled, hypertetraploid number occur at frequencies between 1 and 5 per cent.

Following Kaziwara's approach of 'immunoselection', that is, taking advantage of the increased

Table 1. PROPERTIES OF THE THREE SUB-LINES OF THE EHRLICH ASCITES TUMOUR

| Property | Tumour line *ELD* | *ELT* | *ELTD* |
|---|---|---|---|
| Proportion of hypertetraploid cells | < 5 per cent | > 85 per cent | < 5 per cent |
| Modal chromosome number | 46 | 92 | 46 |
| Average cell volume* | 1,368 ± 47 $\mu^3$ | 2,238 ± 67 $\mu^3$ | 1,370 ± 51 $\mu^3$ |
| Average deoxyribonucleic acid per cell† | 11·1 ± 0·5 × $10^{-9}$ mgm. | 20·6 ± 1·1 × $10^{-9}$ mgm. | |

* Determined according to ref. 9.
† Determined according to ref. 10.

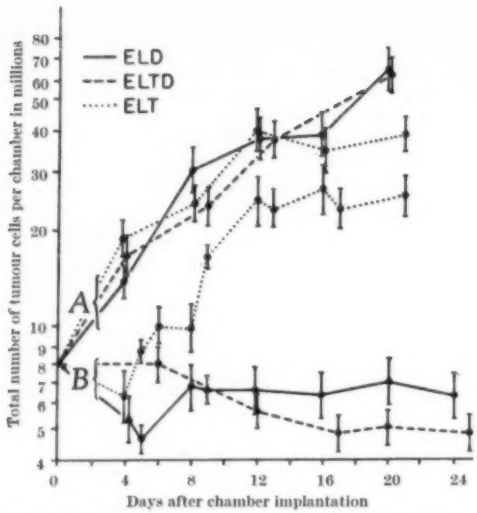


Fig. 1. Growth of hyperdiploid *ELD*, *ELTD*, and hypertetraploid *ELT* in diffusion chambers after inoculation of $8 \times 10^6$ untreated cells and after irradiation with 2,000 r. The geometric mean and its standard error are indicated. The means have been calculated from 2–10 separate chambers in 1–3 separate experiments. The standard errors were obtained from calculations based on 17 duplicate and 6 triplicate determinations. *A*, untreated lines; *B*, irradiated lines

resistance of hypertetraploid cells to the homograft reaction as compared to the hyperdiploid cells[6], a predominantly (more than 85 per cent) hypertetraploid sub-line was derived from *ELD*, after homotransplantation of $20 \times 10^6$ cells irradiated with 4,000 r. (ref. 4). The new line was designated *ELT* and had a modal chromosome number of 92. The X-ray dose damaged the majority of the cells irreversibly. Such lethally damaged cells may strengthen the homograft reaction considerably[8] and increase its selecting effect on the small viable remainder of the population. The ratios of modal chromosome number, average cell volume, and average amount of deoxyribonucleic acid per cell were approximately 1 : 2 when *ELD* and the first three consecutive transplant generations of *ELT* were compared (see Table 1 and ref. 4). In agreement with the findings of Kaziwara[6], hyperdiploid cells had a proliferative advantage over hypertetraploid cells in the absence of immunoselection[4] and the population of *ELT* shifted back gradually towards the predominance of hyperdiploid cells in the course of serial transfer with large ($20 \times 10^6$) cell doses. The tumour line derived from *ELT* after fifteen such passages, designated *ELTD*, was cytologically indistinguishable from the main *ELD* line.

In a series of experiments, $8 \times 10^6$ untreated or irradiated cells of the three sub-lines were grown intraperitoneally within diffusion chambers of a modified Algire type[11]. The conditions of irradiation *in vitro*, the construction and sterilization of the chambers, and the method of introducing the cells are being published elsewhere[12]. 'Millipore' filters of *HA* type (Millipore Corporation, Bedford, Mass.) with a pore size of 0·5$\mu$ were used in order to protect the graft from the influence of cellular host reactions provoked by transplanted, irradiated cells[8,12]. Such reactions (inflammatory reaction, accelerated stroma formation, increased vascularization, homograft reaction, etc.) may have a stimulating or an inhibiting effect on tumour growth, and may therefore interfere with the testing of cellular radiosensitivity. The cell impermeable filter membrane permits the diffusion of soluble material, but prevents the pre-irradiated graft from having direct contact with host cells.

The cell content of the chambers was determined quantitatively at various intervals after inoculation. The technique is being described elsewhere[12]. The growth characteristics of the three sub-lines were closely similar when untreated. They differed clearly with regard to their response to radiation, however. After a dose of 1,000 r., the total number of *ELT* cells was consistently larger than that of *ELD* or *ELTD* at corresponding times during an observation period of 16 days. *ELT* cells, treated with 2,000 r. or 3,000 r., increased in number three- and two-fold, respectively, by the end of the third week after inoculation. No detectable increase of the *ELD* and *ELTD* populations occurred after treatment with the same X-ray doses. Irradiation with 4,000 r. inhibited the growth of all lines completely. The growth behaviour of the untreated cells and the growth curves after treatment with 2,000 r. are illustrated in Fig. 1.

These findings indicate that a difference exists between the radiosensitivity of tumour cell populations of common origin but differing in chromosome ploidy. The change of the radiosensitivity concurrently with the ploidy shift from a hyperdiploid to a hypertetraploid and, afterwards, again to a hyperdiploid dominance, implies that the difference in radiosensitivity can be related directly to the ploidy difference, and is not coincidental to the separate maintenance of the lines.

The question arises whether selection of polyploid cells in the course of radiation treatment may contribute to the development of resistance to radiation in animal or human neoplasms. Recent observations on the change of the deoxyribonucleic acid content associated with the development of resistance to radiation in human uterine tumours may favour this possibility[14].

A detailed report of this work will be published elsewhere.

We thank Prof. G. Klein for his continuous interest in these investigations and his stimulating criticism; and Dr. K. E. Hellström for advice regarding the cytological methods. This work was supported by grants from the Swedish Cancer Society and by Grant *C*-4747 (to G. Klein) from the National Cancer Institute, U.S. Public Health Service.

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# LETTERS TO THE EDITORS

## PHYSICS

### A New Plasma Confinement Geometry

As is well known, the strong synchrotron radiation recently predicted by Trubnikov and Kudryavtsev[1] from a plasma containing a magnetic field at thermonuclear temperatures makes it harder to design a thermonuclear reactor using the deuterium–tritium reaction, and practically impossible to design a deuterium–deuterium reactor. One way to get around this difficulty is to have no magnetic field in the plasma, so that the radiation becomes only a surface phenomenon instead of a bulk one. Of all the magnetic confining geometries at present known, theoretically only one has enough stability to hold a pure (that is, $\beta = 8\pi nkT/B^2 = 1$) plasma. This is the picket fence or cusped geometry[2]. Unfortunately, according to Grad[3], the cusps will be very leaky. Attempts have been made to construct geometries to avoid these leaks by closing the cusps on themselves (compare the most interesting papers by Braginski and Kadomtsev[4]). The same idea was proposed independently by Longmire and me some years ago under the name 'caulked picket fence'[5] (Fig. 1). These geometries involved current-carrying rings, disposed inside a solenoid having a longitudinal magnetic field. Quite apart from the topological impossibility of connecting leads or cooling to these rings without making contact with the plasma, the systems were unstable in their toroidal form because there was no rotational transform[6] in the torus axial field.

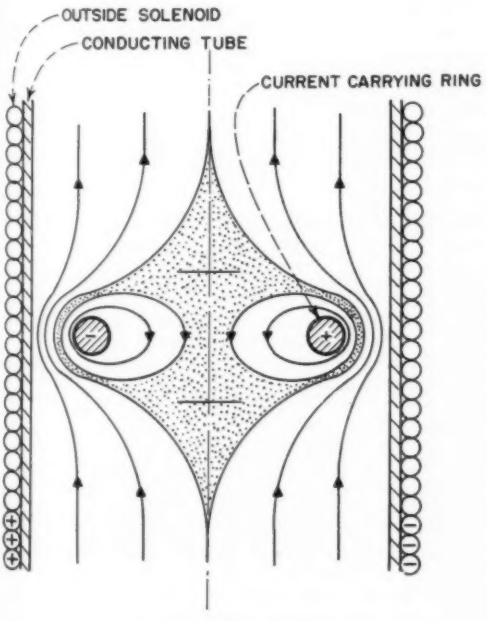


Fig. 1. Caulked picket fence geometry

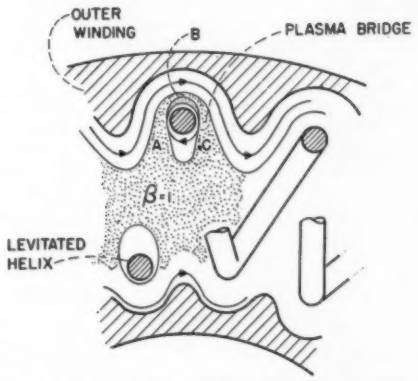


Fig. 2. Toroidal magnetic plasma confinement geometry. The inner spiral is continuous without connexions and floats in the magnetic field. The rotational transform of the field is not shown

During a re-examination of these old ideas, a new geometry (to be known as a helixion) has appeared, based on the helix, which appears to make possible stable $\beta = 1$ confinement with zero cusp losses in a torus. Furthermore, a linear helical system with $\beta = 1$ stable confinement, with cusp losses reducible to an arbitrarily small fraction of the confined plasma in unit time, that can be operated by d.c. and cooled, seems to be possible.

The toroidal helixion is shown in Fig. 2. An external tight helical winding on the torus has linear current density $j$ per unit circumferential length. An internal open helix has mean current density $-j$ (less than this will suffice but involves a sacrifice of the confined volume). The effect of this is to produce a chain of regions along the axis where the field is weakened (there are no neutral points), which are bounded on all sides by magnetic fields of positive curvature. In the limit of infinite plasma conductivity, these places could be occupied by plasma, and be completely stable. However, these regions have cusps—say, $A$ and $C$ which are bridged by a line $B$ encircling the inner conductor. In the region of the bridge, the system has a curvature which is in the sense for hydromagnetic instability. In the old conception (ref. 5 above), it was believed that the regions of the bridge would, since the field there is much larger than that surrounding the main body of the plasma, be largely free from plasma, so that the hydromagnetic instability would convey a negligible amount of plasma to the wall. By reference to the cusp loss theory of Grad[3], the cusp acts at high $\beta$ like a slit, of width $2\delta$, where $\delta$ is the plasma-field sheath thickness, from which the plasma escapes freely. We now see that line $B$ becomes a connecting bridge (tongue in the words of Kadomtsev) of plasma, having a particle density $n$ no less than that in the main $\beta = 1$ body, although its $\beta$ can be much less than unity, since the bridge field can be much larger than that at the main $\beta = 1$ plasma surface.

Consequently, it is imperative to retain hydromagnetic stability in the bridge. The problem of the hydromagnetic stability of this region much resembles

that of the stellarator, and it is safe to assume that there will be a limiting stable $\beta$, call it $\beta_c$, in the bridge. Then if $B_b$ is the magnetic field in the bridge, $B_1$ at the surface of the main $\beta = 1$ region, the critical density for stability everywhere will be $n = \beta_c B_b^2/8\pi nkT$, $\beta_c = B_1^2/B_b^2$.

Note that the inclination of the helical winding imparts a shear to the field in the bridge region, which is beneficial for stability, increasing $\beta_c$, and that the axial component of the current in the helix imparts a rotational transform to the axial field which is essential for stability in a torus. The current in the helix must be produced by magnetic induction, so the operation is discontinuous. The quantity (reacting volume/wall area) increases with the scale, as does the decay time constant of the induced current, so it is advantageous to make the device large. The magnetic levitation of a plain ring in a torus has already been demonstrated experimentally in connexion with the toroidal hard-core pinch concept or levitron of Colgate and Furth[7].

So far, in this hypothesis we have $\beta = 1$ stable confinement, with no cusp losses. Only the plasma in the bridges and surface sheaths will give synchrotron radiation. However, it would be idle to pretend that this object is simple from the practical point of view. The discontinuous operation is a disadvantage and it is difficult to cool the helix.

For the extension of this idea to an open-ended helixion, consider the cusped region that could be occupied by a plasma in the vicinity of the neutral point produced by a straight current-carrying wire, in a transverse magnetic field. Such a region has two cusps which are bridged around the wire, and two cusps which connect to the outside world. The plasma region does not touch the wire. Now it turns out that as the inclination of the wire to the magnetic field is reduced, the cusped region shrinks, and ultimately vanishes, without touching the wire. For a uniform magnetic field of magnitude $A$, and a plasma in pressure equilibrium with a field $\alpha A$ ($\alpha < 1$), the cusped region vanishes when the angle between the axis of the wire and the field is $\cos^{-1}\alpha$. The proof must be reserved for a longer communication.

Now consider a straight long solenoid having in it a helix as in the right-hand side of Fig. 3. The magnetic field is greatly reduced on the axis and is large between the helix and the wall. For connexion of the helix conductor to a source of d.c. current and for cooling, the helix is opened up, increasing the inclination of the turns to the axis, so that it ultimately emerges from the end as an axial conductor. The main bulk of the plasma has bridged cusps, and is connected to the outside world solely at the ends via a ring cusp. Now the losses from the end cusps are independent of the length, and the system can be made very long, since the solenoid can be supported magnetically. As with the torus, the system becomes energetically more profitable as the solenoid radius is increased. Most (possibly all) of the magnetic lines can be made to terminate at the ends of the system. This means that the mean stream of quiescent cross-field diffusion from plasma to wall can, if desired, be intercepted at the ends in the manner of a diverter[4].

Helpful criticism by H. Dreicer and T. H. Stratton is gratefully acknowledged.

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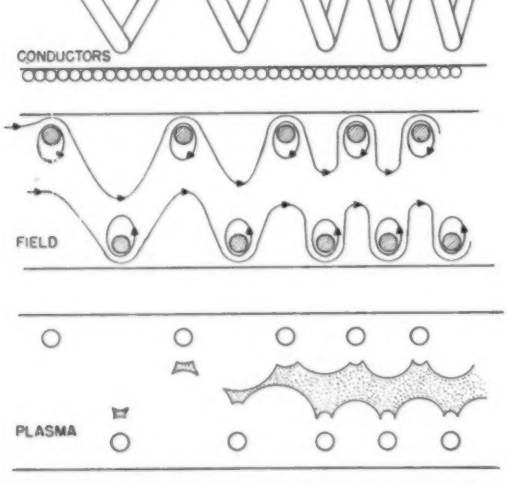


Fig. 3. Linear magnetic plasma confinement geometry with transition to outside connexion on the left. The spiral configuration of the field lines and the plasma bridges are not shown

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## Thermal Conduction in Mica along the Planes of Cleavage

A number of measurements on the thermal conductivity of mica perpendicular to the cleavage planes have been carried out in the past[1,2]. However, apart from the work of Jannetaz[3], which suggests that the thermal conductivity is highly anisotropic, no data appear to be available relating to conduction along the planes. We report here the results of some measurements, with heat flow along the planes of cleavage, on phlogopite, a type of mica which is effectively uniaxial and isotropic within the layers.

We employed two different experimental methods. In the first of these, the thermal conductivity was obtained directly using an absolute method[4]. A block of mica, which was built up from a large number of sheets, was cemented with 'Araldite' between two copper plates. The thermal resistance of the mica block was obtained by subtracting the resistance of the layers of adhesive from the measured overall

resistance. The thickness of the mica block, perpendicular to the cleavage planes, was found from its weight; it was thought that a direct measurement of the thickness would have been inaccurate owing to the composite nature of the sample.

The thermal conductivity was also determined indirectly from the thermal diffusivity, using the apparatus described by Green and Cowles[5]. Temperatures were measured with 46 s.w.g. chromel-alumel thermocouples inserted in the composite mica sample. In calculating the thermal conductivity, a specific heat of 0·86 joule/gm. ° C. was assumed[6].

The results obtained by the two methods were in good agreement with each other. The indirect method yielded a value of 0·0190 cm.²/sec. for the thermal diffusivity at 27° C., leading to a thermal conductance of 0·0163 ± 0·0009 W./° C. for a rectangular block 1 cm. long, with a mass of 1 gm. Using the direct method, this quantity was found to be 0·0185 ± 0·0018 W./° C.; within the limits of experimental accuracy, it showed no variation over the temperature range −85° to 35° C. Thus, assuming a density of 2·8 gm./c.c. (ref. 6), the values for the thermal conductivity corresponding to the two methods are 0·046 and 0·052 W./cm. ° C. respectively.

It is concluded that the thermal conductivity of phlogopite along the planes of cleavage is about 0·05 W./cm. ° C. This is an order of magnitude greater than the values which are typical for the perpendicular direction[1].

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## Measurement of Slip (*Ko*) and Viscous (*Bo*) Flow Coefficients of Permeable Solids

It is usual to measure the slip (*Ko*) and viscous (*Bo*) flow coefficients of permeable solids by plotting $K = \frac{u_1 p_1}{\nabla p}$ as a function of mean specimen pressure $\bar{p}$, and using the slope and intercepts of the curve to find *Bo* and *Ko*. It is also possible to find *Bo* and *Ko* in one measurement (at a single $\bar{p}$), of $K$, $p_1$ (inlet), $p_0$ (outlet) and the centre-specimen pressure. By knowing that the mass flow:

$$Q_m = -\frac{MA}{RT} K(\bar{p}) \frac{\partial p}{\partial z}, \text{ that } K = a + b.\bar{p}$$

$$\text{where } a = Ko.\frac{4}{3}\sqrt{\frac{8RT}{\pi M}}$$

and $b = Bo/\eta$ ($\eta$ is gas viscosity), and that the divergence of $Q_m$ is zero ($Z$ − axial flow only, that is, a rod or bar test-piece), a pressure distribution $p(Z)$ can be calculated; by putting $p(Z) = p(\frac{1}{2})$, that is, pressure half-way along the bar-length ($Z = L/2$), $a/b$ can be found as:

$$\frac{\frac{1}{2}(p_1^2 + p_0^2) - p^2(\frac{1}{2})}{2\,p(\frac{1}{2}) - (p_0 + p_1)}$$

by measurements of pressures at three points, independently of flow. Since $K = b.\bar{p}\left[1 + \frac{a}{b}.\frac{1}{\bar{p}}\right]$, by finding $K$ from flow measurements, $b$ can be found, and hence $a$: that is, *Bo* and *Ko* can be found.

$p(\frac{1}{2})$ = R.M.S. value, $\sqrt{\frac{p_1^2 + p_0^2}{2}}$, for the case $Ko = 0$, and $= \bar{p}$ when *Bo* is zero.

It is hoped to publish this method fully elsewhere.

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# ASTROPHYSICS

## Temperatures reached in Electrical Discharges in the Solar Atmosphere

In a contribution[1a] to the Institution of Electrical Engineers Convention on Thermonuclear Processes, of which a somewhat fuller account was published later in *Nature*[1b], I suggested that the electrical discharge theory of solar flares and the associated magnetic storms and auroræ led to the surprising result that the temperature of these discharges must reach values of the order of 100,000,000° K. somewhere between the Sun and the Earth's orbit. In another account[1c] of this work, I suggested that this need not come as too great a surprise, as temperatures of the order of 1,000,000° K. had been obtained some years earlier in electrical discharges in the laboratory (I. V. Kurchatov, Moscow, 1956), and for long have been known to exist in the solar corona.

Furthermore, a similar increase in temperature is observed when long electrical discharges are propagated down the corresponding, but lesser, density gradients in some stellar atmospheres—those of the combination spectra stars, such as *Z* Andromedæ and *AX* Persei, for example. In these the temperature is initially that leading to the ionization of the metals, hydrogen and helium, that is, probably of the order of 5,000° or 10,000° K. However, by the time the discharge reaches the outer regions of these stellar atmospheres, after periods of the order of 100–200 days, the discharge temperature reaches values of the order of 1,000,000° K. as lines of Fe X and Fe XIV appear in the star's spectra.

Though there was thus some additional theoretical support for the surprising conclusion to which the theory led when applied to these solar phenomena, it is satisfactory to learn that satellite observations made by the U.S. Navy scientists have confirmed[2] that these high temperatures do exist in the disturbances associated with solar flares. As I emphasized many years ago[1d], it is difficult to see how these high temperatures can be built up by any other mechanism than that of an electrical discharge.

Similar temperatures are reached in galactic electric discharges, and can be measured, as I have suggested, by the proposed 'cosmic gas-velocity thermometer'[1e], of which the basic conception is that these high gas velocities observed in stars and galaxies are always the result of electrical discharges, the velocities of these jets being linked closely with their temperatures[1f], in contradistinction to the assumptions

often made in other accounts of these solar jets[3]. The only limit to the discharge temperature will be the onset of thermonuclear processes[1,g].

On the electrical discharge theory of galactic evolution[1,d,g] the main difference between the gas which ultimately forms Population I stars, and that which originally formed Population II stars, is that the former has been subjected to 'thermonuclear temperatures' of the order of 400,000,000° K. for a period of the order of 10–100 million years, during the formation of the spiral arms. It may be, therefore, that it is this difference which has led to the difference in the proportions of the heavier elements observed in these two stellar populations. It is not easy to visualize all the physical characteristics of electrical discharges on such a scale as that envisaged, but at present the value of $n$, the number of atoms per cm.[3] of the galactic atmosphere, required to effect the observed chemical change in the time available, appears to be too high. However, it would be interesting to have comments on this suggested explanation of this difference between the two stellar populations.

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## The Sudden Discontinuity in the Orbital Period of *Sputnik* 4 Satellite

The orbit of the fourth Russian Earth satellite soon after its late launching on May 14, 1960, was similar to the orbits of the previous *Sputniks*, as may be seen from the orbital elements shown in Table 1. A Tass News Agency report of May 17 indicated that there were two objects close together in orbit—the composite satellite itself, consisting of a 'space capsule' attached to an instrumental section, and the last stage of the launching rocket. The instrumental section included a transmitter or transmitters radiating on frequencies of 19·996 and 39·992 Mc./s., as measured at the Radio Research Station, Slough. The first radio directional observations from the United Kingdom were made at the Radio Research Station on transits occurring at about 1054 hr. and 1225 hr. U.T. on May 15. The first reported visual observation from Western Europe of the composite satellite and rocket was made from Meudon at about 0325 hr. U.T. on May 16.

The radio observations of the transmitting component made before May 19.0 indicated that the satellite was behaving normally, the nodal period dropping by about 0·3 sec./day. However, radio observations made after this time indicated that the satellite was reaching northern apex progressively later on each revolution, and by 1200 hr. U.T. on May 19 its transits were some 25 min. later than predicted. Interferometer observations made at the Radio Research Station indicated that the inclination of the orbit had not appreciably altered, and so an increase in orbital period was suspected. A comparison between predicted and observed apex times was made from transits before and after 00 hr. U.T. on May 19, and the differences have been plotted against the observed apex times (Fig. 1). The plot consists of two distinct linear distributions of points and the intersection of lines fitted to each group lies at 2357 hr. U.T. on May 18. The time of this observed discontinuity in the orbital period coincides very closely with the time of 2353 hr. U.T. at which, according to a Tass News Agency report of May 21, an attempt had been made to bring the 'space capsule' out of orbit. It is of interest to note that at the latter time the satellite was almost exactly at perigee position, the geographical co-ordinates of which were long. 60° E., lat. 54° N., and the path of the satellite lay across the whole breadth of the U.S.S.R. The slope of the plot after the discontinuity implies an increase of period of approximately 3 min. from about 91·2 min. to 94·3 min., and the elements of the orbit after this time are shown in Table 1.

Table 1. Orbital Elements of *Sputnik* 4 Satellite

| | Before approx. 00 hr. U.T. May 19 | After approx. 00 hr. U.T. May 19 |
|---|---|---|
| Mean nodal period | 91·18 min. | 94·26 min. |
| Semi-major axis | 6,711 km. | 6,861 km. |
| Eccentricity | 0·004 | 0·026 |
| Argument of perigee | + 61° | uncertain |
| Inclination | 64·89° | 64·89° |
| R.A. of ascending node | 254·3 | 254·3 |

At about 0741 hr. U.T. on May 19, the originally composite satellite was observed visually from Canada as two close components which are now slowly separating. The leading component has been identified by directional radio observations made at the Radio Research Station, Slough, as the transmitter section. Later observations indicated the presence of more than two components in approximately the same orbit as the transmitting section: visual observations on a total of five objects in this orbit have reached us.

The information available from the Tass report of May 21 indicates that the 'space capsule' was appar-

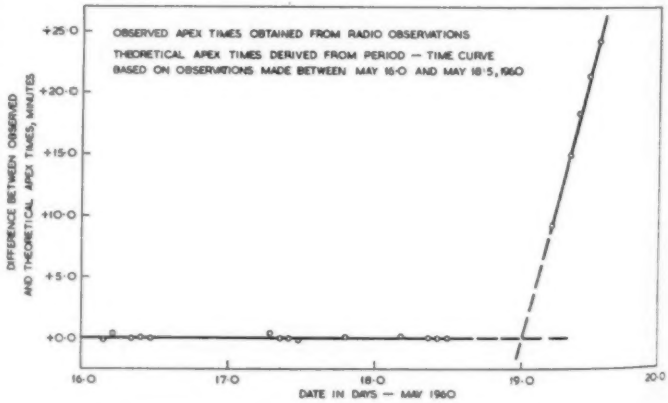


Fig. 1. Discontinuity in nodal period of transmitting component of *Sputnik* 4

ently intended to leave the orbit from near the perigee position by means of a retro-rocket system. The observed discontinuity in the orbital period of the satellite seems to suggest that the satellite was misaligned at the time of firing and, as a consequence, the retro-rocket placed both the capsule and the transmitting section into a higher orbit than that of the rocket.

The work described above was carried out as part of the programme of the Radio Research Board, and is published by permission of the Director of Radio Research of the Department of Scientific and Industrial Research.

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## OCEANOGRAPHY

### Ocean Currents in McMurdo Sound

Measurements of ocean currents in McMurdo Sound, Antarctica, were made during May and June 1959, by measuring the potential differences developed between three silver–silver chloride electrodes hung in the sea below the ice.

Initially the electrodes were placed in the sea at the same location to determine the contact potentials and to estimate their variations. The electrodes, labelled *N*, *W* and *S*, were then placed out, *N* 500 m. north and *W* 500 m. west of the third electrode *S* which was 5 km. from Scott Base (77° 51′ S. and 166° 48′ E.) and on a line bearing 200° from it. The electrodes were connected by cable to Scott Base where the potentials between adjacent pairs were recorded by a four-point Honeywell Brown recorder.

On magnetically disturbed days the records were too disturbed to be of use. The records from calm days were selected and the values recorded by each adjacent electrode pair were averaged over a whole day, thus eliminating the tidal effect, which was mainly diurnal, leaving the general ocean drift. Since the instantaneous sum of the *N*–*S* and *S*–*W* potential differences equalled the *N*–*W* difference, the averages found for the respective channels should agree likewise.

For the purposes of calculating the currents it was assumed that there was a uniform flow in a straight channel. After consideration of the formula derived by Longuet-Higgins[1] for flow in a semi-elliptical channel, it was assumed that the shape of the channel and the conductivity of the bedrock were in this instance not important factors. A value of 0·69 oersted was used for the vertical component of the Earth's magnetic field. The results of the analysis of 18 days records are listed in Table 1, giving a mean velocity of 7·5 cm. sec.$^{-1}$ in a direction 44° east of north. Short-term current meter readings were in general agreement with this mean. These results indicate a different direction of drift past Cape Armitage (from McMurdo Sound towards the Ross ice shelf) from that which has been observed during summer months[2].

Lead strip electrodes, placed on the surface of the ice, which was 2 m. thick, were tried also; but the experiment had to be abandoned before conclusive results could be obtained, although the few records obtained indicate that despite a larger contact potential it would be possible to get useful results.

A more detailed account of these measurements, together with associated hydrological and tidal observations, is in preparation.

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## GEOLOGY

### Average Composition of Granites, the Genesis of Tektites, and Petrogenesis

The recent article by Lovering[1], in which the average chemical composition of tektites was compared and contrasted with the average composition of terrestrial shales, calcalkaline granites and granophyres, involves an important question which is too frequently ignored. Comparison was made with the average bulk chemical composition of shales (78 analyses from Clark's Tables), granites (72 analyses quoted by Nockolds) and acid granophyric differentiates of basic magma (35 analyses available in the literature). As a basis of discussion, it may be assumed that the bulk chemical analyses are accurate representations of each of the 185 samples involved. Probably it is reasonable to assume that each of the 185 specimens was chosen by a competent geologist as a 'typical sample' to represent the rock-mass concerned.

The vast majority of granitic bodies which outcrop at the Earth's surface have received some qualitative but virtually no quantitative study. Thus, there are virtually no granite plutons for which anything like adequate information is available as a basis for determining the quantitative composition of the two-dimensional outcrop (representing the random section through the rock-mass). Even less is known about the three-dimensional composition and variability. At the present time, meagre quantitative data

Table 1. Speed and Direction of Ocean Currents in McMurdo Sound

| | May 1959 | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 1 | 2 | 3 | 4 |
| Velocity (cm. sec.$^{-1}$) | 11·3 | 11·4 | 6·4 | 5·7 | 7·0 | 2·2 | 6·6 | 11·1 | 12·0 | 2·2 | 5·4 | 8·3 | 10·1 | 11·3 | 12·3 | 10·8 | 9·0 | 6·9 |
| Direction, true | 22° | 16° | 10° | 34° | 79° | 36° | 357° | 80° | 76° | 54° | 33° | 24° | 39° | 44° | 71° | 69° | 59° | 0° |

are available for a dozen or so granite plutons. In each case elementary statistical analysis demonstrates that compositional gradients occur in the bulk composition, and one or two 'typical specimens' constitute a totally inadequate sample upon which to base an estimate of the average composition of the target population of specimens comprising the entire pluton. Preliminary results for the 'older granite' of Donegal, Ireland, have been published[2,3] and additional more detailed analyses are in hand. Studies of variability in the Bahalda Road granodiorite (India), the Wollaston and Deloro plutons (Canada), the Beinn an Dubhaich granite (Scotland), and the Mourne Mountain granite *G2* (Ireland) are the subject of a manuscript in the press.

Critical study of these six and several other granite bodies makes it amply clear that for any one granitic mass the arithmetic mean computed for a few 'typical specimens' yields a meaningless value in terms of the average composition of the entire volume of granite. The geologist who collects the 'typical specimens' almost certainly introduces a strong bias in his selection either involuntarily or voluntarily. Hence adequate sampling of a pluton does not require simply the collection of a large number of 'typical specimens', but involves the implementation of a sampling design adjusted to the individual characteristics of the rock mass (cf. Krumbein[4]). So far as is known, no entirely satisfactory sample has ever been taken for an entire granite pluton, so that the average composition of a body of granite cannot be stated accurately in any single case.

In view of the problem involved in assessing the bulk mineralogical and/or chemical composition of a single granite body, the arithmetic mean of bulk chemical analyses of single specimens drawn from 72 separate rock masses will produce a value having little or no precise relationship to the average composition of the target population for the 72 terrestrial plutons. However, if from a collection of hand-specimens derived from different plutons 72 similar samples are selected by a trained geologist, it is highly probable that the average of the individual chemical analyses will represent the average composition of the 72 specimens, but not of the 72 plutons represented.

Apart from the average composition, reasonably complete sampling in the few masses studied quantitatively shows that a large range in modal and normative composition occurs in each rock-mass. This is contrary to the impression given by the usual published ternary diagrams (both normative and modal) based upon one 'typical specimen' from each of a large number of complexes. In the latter case the points naturally cluster closely together (cf. Tuttle and Bowen[5]), and in the former are scattered widely on the ternary diagrams.

Hence, whether the composition of tektites is related to analyses of the 72 calcalkaline granites or the 35 granophyres may be interesting; even a very strong positive correlation does not indicate whether the tektites are related to the average composition of granite massifs of broadly calcalkaline affinities or to granophyric differentiates. Similar arguments apply with equal force when a few 'typical specimens' are employed to draw comparisons between the bulk quantitative composition of different rock-masses, and also when such samples drawn from different areas are employed as the bases of petrogenetic theories. However, in geological discussion considerable significance is usually attached to such average chemical and mineralogical values. This subject is developed more extensively, and illustrated by quantitative data, in a further manuscript awaiting publication.

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## Nomenclature of the Keuper Series

In the announcement in *Nature*[1] of the most interesting results of the recent borings penetrating the Trias of the Cheshire Plain, the Director of the Geological Survey made certain suggestions for the nomenclature of the subdivisions of the Keuper Series which, if adopted, may result in considerable confusion. The Keuper Series has, in the past, been subdivided into Keuper Marl and Keuper Sandstone rather than into Upper Keuper and Lower Keuper respectively, although Wills[2] calls the latter usage the "traditional classification". Keuper Marl and Keuper Sandstone were originally what we would now call rock-stratigraphical units which have acquired a time-stratigraphical significance even though this is probably not justified in view of the paucity of fossils in the Trias and the weight that has to be placed on lithological correlation. Difficulties have not arisen to any serious extent, because the subdivisions of both stages of the Keuper have been in rock-stratigraphical units and have been applicable to quite large but distinct areas. It is also of importance that the terms Lower, Middle and Upper Keuper are in use in Germany which, after all, was the type area, and that, at the moment, there is uncertainty concerning correlations suggested by the flora and fauna of the Bromsgrove Keuper Sandstone with the Lettenkohle and the Muschelkalk of Germany and the Grés à Voltzia of Alsace.

The new subdivisions proposed for Cheshire are likely to be confusing because of the use before Keuper of the words 'Lower', 'Middle' and 'Upper', particularly with capital letters, which implies a time significance within the Keuper Series. For example, Lower Keuper Marl is intended to indicate a formation in the lower part of the Keuper Marl, that is, lower Upper Keuper. As pointed out above, Lower Keuper is not, in fact, now normally used by British stratigraphers to indicate the Keuper Sandstone, but to someone not familiar with the stratigraphy of the British Trias the term immediately suggests a marl in the Lower Keuper, that is, in the Keuper Sandstone. The same sort of criticism may be made of the other four subdivisions and of the term Upper Keuper Sandstone.

The provisional names suggested for the Keuper Sandstone raise additional difficulties. In the past[3,4], the Upper Keuper Sandstone has been the name given to what is now normally known as the Arden Sandstone[4], which truly belongs to the upper part of the Keuper Series. It is noteworthy that, to eliminate confusion, the term Arden Sandstone is used virtually exclusively nowadays. Furthermore, Hull[5] used Lower Keuper Sandstone to cover the whole of the Keuper Sandstone, and the use of Upper Keuper

Sandstone to indicate the upper part of the Keuper Sandstone is most undesirable.

Those who have been compiling the "Lexicon of Stratigraphy" have good cause to know the confusion which reigns as a result of the indiscriminate use of 'Lower', 'Middle' and 'Upper', and many similar examples in British stratigraphy could be quoted. It is to be hoped that the Geological Survey, particularly bearing in mind the German usage, will not now add new sources of difficulty at a time when it is widely agreed that there is great need for some simplification and clarification of the nomenclature.

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THE Geological Survey of Great Britain produces geological maps distinguishing strata with particular lithological characters and ages; thus Chalk is singled out from other limestones and given a particular colour on small-scale geological maps; on larger-scale maps certain hard bands have been used to divide the formation into Lower, Middle and Upper Chalk; likewise, some argillaceous strata of widespread distribution containing marine fossils are now used to divide the Coal Measures into Lower, Middle and Upper Coal Measures.

In the recent article on Triassic Salt in the Cheshire and Shropshire Basin, it was shown that two horizons of Saliferous Beds would be used to divide the Keuper Marl formation into Lower, Middle and Upper divisions in Cheshire. This will replace the older division into Lower and Upper Keuper Marl, which was used, for example, on the 1958 edition of One-inch Sheet 97 (Runcorn) before the Upper Saliferous Series was known to exist[1].

The use in geology of saliferous horizons as indicators of the past existence of particular climatic conditions over wide areas is not new. Accordingly it is considered that Lower, Middle and Upper Keuper Marl are legitimate terms for the depiction of strata on the geological map, and that to describe such usage as "indiscriminate" is misleading. It is well known that the British nomenclature of subsystemic units is far from ideal; and from time to time the Geological Survey is obliged to accommodate new discoveries by division of time-honoured units, in the present instance the Keuper Marl. In making this particular decision, the names Lower, Middle and Upper Keuper Marl were considered suitable; and no alternative was considered, such as the invention of stratal names based on localities. Such a course may well be taken, however, when investigations are completed on the beds "provisionally called Upper Keuper Sandstone".

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## METALLURGY

### Non-crystalline Structure in Solidified Gold-Silicon Alloys

EXCEPT for thin films deposited at very low temperatures[1], highly disordered arrangements of the atoms, similar to that of the liquid state, have never been observed in solid metals and alloys. For some metalloids, the bonding of which may actually be more covalent than metallic, such amorphous configurations have been retained in the solid state[2] by cooling from the melt with sufficient celerity so as to prevent formation of the equilibrium crystalline structures.

It is thus conceivable that such non-crystalline structures can be obtained for some, perhaps all, metals and alloys by quenching rapidly enough from the molten state. In the course of experimentation with the apparatus developed by us[3], an amorphous structure has been detected in a 25 atomic per cent silicon–gold alloy which was quenched from $\sim 1{,}300°$ C. to room temperature.

The quenched alloy was studied by means of X-ray diffraction. A flake (area $\sim 0{\cdot}2$ mm.$^2$; thickness $\sim 10\mu$) was mounted in a Debye–Scherrer camera and exposed to copper $K$ radiation. Intensity (on an approximately linear scale), as obtained from the film with a microphotometer, is plotted against $\sin\theta/\lambda$ in Fig. 1.

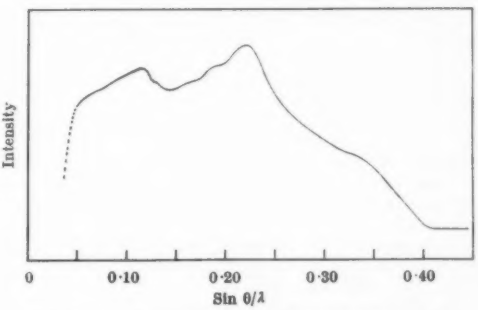


Fig. 1. X-ray diffraction pattern of gold-silicon alloy

It is to be emphasized that the amorphous foil is quite unstable at room temperature (and it is entirely possible that some decomposition could have occurred during the 3-hr. exposure). The decomposition products detected after 24 hr. at room temperature have complex crystal structures, involving $d$-spacings of the order of 11–12 Å. It is quite probable that many phases may be present under these non-equilibrium conditions. However, at this stage of decomposition, the equilibrium phases are definitely not present.

Since the synthesis and investigation of these amorphous foils are highly uncertain under the present experimental conditions, refinement of the apparatus so as to permit operation at liquid-nitrogen temperatures is now under way. Among the various facets of such non-crystalline metals and alloys which might be of interest, possible superconducting properties should be considered—especially since Buckel[1] has observed that certain metals in thin evaporated layers (amorphous structure) become superconducting at somewhat higher temperatures than with the normal crystal structures.

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## CHEMISTRY

### New Compounds for the Control of Water Evaporation

Considerable attention has lately been directed towards effective suppression of water evaporation from lakes and reservoirs by spreading insoluble monomolecular films over the water surfaces[1,2]. In order to be effective, the film-forming compound should have several desirable properties[3] such as: (i) low melting point (~50° C.), which will enable it to spread rapidly on the water surface so that its monomolecular film, if damaged, is easily healed; (ii) large equilibrium film pressure at the temperatures of water surfaces (15–40° C.) normally met with in practice; (iii) the film formed should be stable, incompressible and condensed.

Cetyl alcohol exhibits most of the above properties to a fair extent and therefore has been used as such or mixed with stearyl alcohol[4] in field experiments. However, laboratory experiments indicate that at 15–20° C. cetyl alcohol shows a reduction of evaporation of about 60–65 per cent, and at 30–35° C. the resistance is much lower (30–40 per cent) (Fig. 1). In field experiments such films show even lower resistance and are also not durable, since their resistance has been found to decrease rapidly in the course of 24 hr. or so. The influence of ambient temperature on the efficiency of cetyl alcohol film has been considered by Ramdas[5] and by others[1].

The higher homologues of cetyl alcohol should be more efficient but for their higher melting points. Substitution of the —OH group by a less active polar group no doubt gives rise to compounds with lower melting points, but the films formed by them are generally compressible[3,6] and give poor performance.

Further, the films formed by most of these compounds deteriorate rapidly due to decomposition, hydrolysis or reactions with the impurities present in the underlying water.

The unsaturated alcohols have lower melting points, but in these, apart from their higher instability, the *cis*-alcohol (for example, oleyl alcohol, melting point ~5° C.) has a 'bent-chain' structure[6] and thus gives rise to non-compactness. The *trans*-alcohol (for example, elaidyl alcohol, melting point 36–37° C.) also does not yield an efficient film. On the other hand, it was considered that the introduction of an additional oxygen atom at the polar end of the saturated compounds would disturb the periodicity of the chain a little and the melting point would also be lowered slightly. Such a modification in the carbon chain would thus permit the use of longer-chain compounds.

A series of compounds $CH_3(CH_2CH_2)_n—OCH_2CH_2—OH$ (referred to as *R*—OEtOH) were, therefore, prepared by reaction of the bromides of pure myristyl, cetyl, stearyl and behenyl alcohols with mono-sodium glycolate and purified by fractional distillation and crystallization. Experiments are also in progress to prepare similar products [*R*—$(OCH_2)_n$—OH] by the direct condensation of *R*—OH with ethylene oxide. A study of these compounds will, *inter alia*, allow us to determine the maximum number of molecules of ethylene oxide to be attached to an alkyl chain in order to obtain the most efficacious film-forming product.

To test the efficacy of retarders of water evaporation in the laboratory, 0·32 ml. of 0·09 per cent solutions of these compounds in 'Analar' (60–80) petroleum ether was spread over a clean water surface in a 9-cm. diameter Petri dish which, with a control dish, was kept on thermostatted metal bases and exposed for an hour to a breeze of 1–1·5 m.p.h. The films of pure cetyl, stearyl and behenyl alcohols were also tested under similar conditions. The reduction of percentage evaporation was calculated from the loss of water in the two dishes, and the results are plotted against the temperature (Fig. 1).

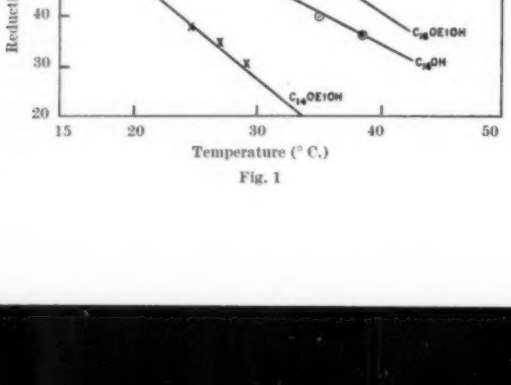


Fig. 1

It was found that, for the normal alcohols, the reduction in water evaporation increases with the chain-length in the temperature-range studied, and the efficacy of the $C_{14}$- to $C_{18}$-alcohols increases steadily with the decrease in temperature. However, at lower temperatures, for the $C_{18}$-alcohol the curve tends to flatten whereas that for $C_{22}$-alcohol shows a decrease in evaporation resistance. This behaviour of the $C_{18}$- and $C_{22}$-compounds may be attributed to the difficulty of their spreading at low temperatures.

That the higher homologues of similar compounds with lower melting points show less difficulty in spreading is also borne out by the corresponding curves (Fig. 1) for the *R*—OEtOH products. In these, although the reduction of evaporation changes generally in the same way as that for the alcohols, it is greater and more persistent and there is scarcely any flattening of the curve except for $C_{22}$-OEtOH, which is surprisingly flat over the range of temperatures studied, indicating that the efficacy remains nearly the same throughout. An equimolar mixture of $C_{18}$-OEtOH and $C_{22}$-OEtOH shows reduction of evaporation intermediate between that of the two, as is also observed for similar alcohol mixtures. However, the efficacy of this film tends to be better

than that of either component alone at lower temperatures, indicating the relative ease of spreading of, and formation of more compact film by, such a mixture as compared to that of the components.

Similar results were obtained on evaporimeter pans of 4 and 8 ft. diameter kept in an open field during different seasons and varying wind velocities (3–12 m.p.h.). Here also $C_{18}$-OEtOH and $C_{22}$-OEtOH consistently gave better reduction of evaporation than cetyl alcohol by at least 30 per cent in summer as well as in winter, and this was corroborated by laboratory experiments at various temperatures. The *R*—OEtOH films were also much more durable than the *R*—OH films, in that the effect of the former lasted for a period of about seven days in contrast to a day or so of the alcohols.

It may therefore be concluded that: (i) the selection of compounds for optimum suppression of water evaporation should be made keeping in view among other conditions the ambient temperature-range; (ii) *R*—$OCH_2CH_2OH$ or *R*—$(OCH_2CH_2)_n$—OH types of compounds are better evaporation retarders than either cetyl or stearyl alcohols; and (iii) the $C_{18}$-OEtOH in colder season (~ 10–20° C.) and either $C_{22}$-OEtOH or its mixture with the former, during the summer (~ 25–35° C.), should prove more suitable in practice.

The process for the preparation and use of the new compounds (glycol mono alkyl ethers) for water evaporation control are being patented[7]. The results of fundamental studies on the specific resistance to evaporation, two-dimensional viscosity, rate of spreading, compressibility, phase behaviour, etc., of these and related compounds and their mixtures will be reported elsewhere.

We acknowledge the help given by Dr. L. G. Shah in the synthesis of the various compounds.

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## Character of the Ligands in Dibenzene Chromium

There has been considerable discussion concerning the molecular symmetry of dibenzene chromium, $(C_6H_6)_2Cr$ (refs. 1 and 2). Theoretical considerations led Ruch[3] to the assumption of a three-fold symmetry of the benzene ligands in the complex, the rings probably being slightly puckered[4]. Fritz and Lüttke[5] stated that the infra-red absorption spectrum of $(C_6H_6)_2Cr$ was incompatible with six-fold symmetry and proposed molecular symmetry $D_{3d}$. Recently, however, the same investigators[6] changed their interpretation of the spectrum; they proposed symmetry $D_{6h}$ both for the molecule $(C_6H_6)_2Cr$ and for the cation $(C_6H_6)_2Cr^+$; this conclusion was based on a study of the infra-red and Raman spectra, mainly of $(C_6H_6)_2CrI$. Snyder[7] also proposed an assignment of the infra-red spectrum of solid dibenzene chromium based on molecular symmetry $D_{6h}$. Six-fold symmetry of the benzene ligands is also assumed by most other investigators in the field of arene metal compounds[8,9].

In view of the importance of dibenzene chromium as the parent compound of the class of arene metal complexes I have undertaken a refinement of the crystal structure of $(C_6H_6)_2Cr$. The outlines of the structure had already been determined by Weiss and Fischer[9]. These authors found the compound to be cubic with cell edge $a = 9{\cdot}67 \pm 0{\cdot}03$ Å. and four molecules per unit cell. The derived space group $Pa3$ immediately led to a centrosymmetric 'sandwich' structure of the molecule, the packing of the molecules being similar to that in solid carbon dioxide. Assuming molecular symmetry $D_{6h}$, they derived distances C—C of $1{\cdot}38 \pm 0{\cdot}05$ Å. and Cr—C of $2{\cdot}19 \pm 0{\cdot}10$ Å. by trial and error.

My refinement is based on three-dimensional X-ray diffraction data which were obtained by Dr. I. Lindqvist and Mr. R. D. Rosenstein at the Chemical Institute of the University of Uppsala, Sweden. The data comprise the visually estimated intensities of 177 independent reflexions, covering 3,560 points of the reciprocal lattice. Refinement of the structure, mainly by difference syntheses, was straightforward. Extinction difficulties, such as described in the comparable case of the refinement of ferrocene[10], were not encountered to an appreciable extent. At the present stage the disagreement factor *R* amounts to 0·063 and for further refinement the anisotropy of the temperature motion must be taken into account. As this may be rather time-consuming, we feel justified in reporting our preliminary results.

Space group $Pa3$ was confirmed by us, and the cube edge was determined to be 9·667 Å. The molecular symmetry of $(C_6H_6)_2Cr$, however, was found to be distinctly different from $D_{6h}$. In the $C_6H_6$ ligands C—C bonds of length 1·353 Å. alternate with bonds of 1·439 Å., molecular symmetry $D_{3d}$ being imposed by the space group. Since the estimated standard deviation in the C—C bond distances is 0·014 Å., the difference between short and long bonds is highly significant; furthermore, it is far too large to be ascribed to intermolecular interaction. The rings are found to be planar within the limits of accuracy; the distances of the carbon atoms to the mean ring plane are 0·008 Å. with an e.s.d. of 0·007 Å. The bond angles C—C—C are $118{\cdot}9° \pm 1°$ and $121{\cdot}0° \pm 1°$, the distances Cr—C $2{\cdot}135 \pm 0{\cdot}010$ Å. and $2{\cdot}132 \pm 0{\cdot}010$ Å. respectively, which is somewhat shorter than has been reported for chromium arene carbonyls[11]. The distance of Cr to the mean ring plane is $1{\cdot}613 \pm 0{\cdot}007$ Å.

In low-angle difference syntheses[12] the hydrogen atoms are clearly visible at the expected distances of the ring atoms. High-angle difference syntheses show the thermal motion to be anisotropic, corresponding to a libration of the rings about the three-fold axis, but certainly not to free or almost free rotation[13]. The root mean square angular amplitude of the libration is approximately 7°, slightly less than in benzene at −3° C. (ref. 14). This libration causes an apparent shortening of the C—C bond distances of the order of 0·010 Å. and of the Cr—C distances

of 0·006 Å.; the bond angles and the planarity of the rings remain unchanged. As stated, the anisotropy of the thermal movement has not yet been taken into account in my structure refinement.

The corrected C—C distances in dibenzene chromium of 1·45 and 1·36 Å. are significantly different from the distance 1·397 Å. found in free benzene[15]. They correspond more closely to the distances found for pure single and pure double bonds between carbon atoms with $sp^2$ hybridization, which have average values of 1·46 and 1·34 Å. respectively[16]. This indicates that little or no delocalization of bonding electrons takes place within the ligands of $(C_6H_6)_2Cr$. The cation $(C_6H_6)_2Cr^+$, on the other hand, possesses one electron less than the neutral molecule; electron spin resonance measurements have shown the unpaired electron to be distributed over the whole ion[17]. This, in its turn, may lead to delocalization of the bonding electrons within the rings and hence to sixfold symmetry of the ion. The chemical implications of the above hypotheses will be described elsewhere.

I wish to thank Dr. I. Lindqvist and Mr. R. D. Rosenstein for giving me their X-ray diagrams and intensity estimations, to Dr. D. W. Smits for adapting his refinement programmes for the electronic computer *Zebra* to the case of cubic symmetry, and to Mr. H. Schurer for performing most of the calculations on the *Zebra*.

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## BIOCHEMISTRY

### Amino-acid Sequence about the Reactive Serine of a Proteolytic Enzyme from *Bacillus subtilis*

An increasing number of hydrolytic enzymes have been reported to be inhibited by di*iso*propylphosphorofluoridate. Where the resulting di*iso*propylphosphoenzyme has been investigated, the phosphate was isolated in the form of phospho-serine peptides and the amino-acid sequence about the reactive serine has been determined in several cases. Trypsin[1] chymotrypsin[2–4], elastase[5,6] and thrombin[7] have the sequence Gly.Asp.Ser.Gly., while horse liver ali esterase[8] and pseudocholinesterase[9] have Gly.Glu.Ser.-Ala.Gly. The proteolytic enzyme subtilisin was isolated from a strain of *B. subtilis* by Güntelberg and Ottesen[10] and they recorded its inhibition by di*iso*propylphosphorofluoridate, while Matsubara[11] obtained a phospho-peptide from strain $N^1$ but did not report any sequence. The present communication deals with an investigation of the enzyme from Novo Terapeutisk Laboratorium known as 'bacterial trypsin', which is similar to, but distinguishable from, the original subtilisin.

A sample was treated with di*iso*propylphosphorofluoridate labelled with phosphorus-32 at *p*H 7·4 and a partial acid hydrolysate was subjected to ionophoresis on Whatman No. 52 paper at *p*H 3·5 in parallel with similarly treated chymotrypsin and liver ali esterase (sample kindly provided by Dr. E. C. Webb). The radioautograph of the ionogram showed that serine phosphate occurred in all three; but the pattern of phospho-peptides from bacterial protease was entirely different from that obtained from either chymotrypsin[4] or liver ali esterase and therefore there must be a different sequence about the labelled site. Repetition of the hydrolysis of samples of di*iso*propylphospho-enzyme, under the same conditions, gave markedly different proportions of the bands within the pattern. The proportions were also affected by subsequent air oxidation and thioglycollic acid reduction, and some individual bands were found to be interconvertible by oxidation or reduction. This suggested that there was, near the labelled serine, an amino-acid which could undergo reversible air oxidation. It seemed probable that this was methionine, which can be readily oxidized to the sulphoxide[12]. The di*iso*propylphospho-enzyme was therefore oxidized with performic acid to convert any methionine into the stable sulphone, and a simplified, reproducible pattern was obtained on hydrolysis. This pattern, which is also obtained if the previous hydrolysates were oxidized with performic acid prior to ionophoresis, is shown in Fig. 1 together with those from di*iso*propylphosphochymotrypsin and di*iso*propylphospho-liver ali esterase.

The interrelationships of these oxidized bands (numbered in diagram) were determined by study of their behaviour to partial acid hydrolysis and Edman degradation[8] and their chromatographic and electrophoretic mobilities. Additional information about the N-terminal residue was obtained by treating the

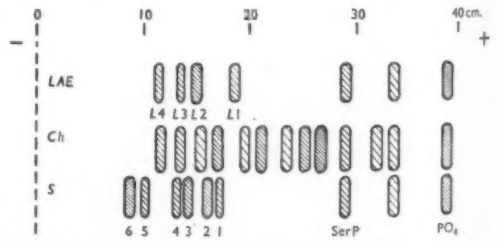


Fig. 1. Diagram of radioautograph of ionogram (*p*H 3·5, 40 V./cm., 2 hr.) of partial acid hydrolysis of di*iso*propylphosphoenzyme derivatives of liver ali esterase (*LAE*), chymotrypsin (*Ch*) and oxidized bacterial protease (*S*). The *LAE* bands are considered to be: *L*1, Glu.SerP.; *L*2, SerP.Ala.; *L*3, Glu.SerP.-Ala; *L*4, Gly.Glu.SerP.Ala. The interpretation of the bands from chymotrypsin is being reported elsewhere (ref. 6)

Table 1

| Peptide | Products of partial acid hydrolysis (excluding $PO_4$ and SerP) | Main radioactive product of Edman degradation | Effect of sodium periodate* |
|---|---|---|---|
| 1 | 1 | $PO_4$ | − |
| 2 | 2 | SerP | + |
| 3 | 1 and 2 | 1 | + |
| 5 | 1 | $PO_4$ | − |
| 6 | 1, 2, 3 and 5 | 5 | + |

* + indicates that the peptide moved faster after treatment; − shows the peptide was not affected.
Peptide 4 is probably a larger peptide the structure of which has not yet been determined.

peptide with sodium periodate solution and observing whether the electrophoretic movement at *p*H 3·5 was affected. N-terminal serine and threonine residues should be oxidized to give a glyoxylic acid residue by loss of ammonia and formaldehyde or acetaldehyde, respectively[12]; so that the radioactive peptide would lose the terminal amino-group and should therefore move faster towards the anode. The results are summarized in Table 1.

A larger sample (50 mgm.) was then treated with di*iso*propylphosphorofluoridate labelled with phosphorus-32, oxidized with performic acid, hydrolysed and the radioactive peptides isolated by paper ionophoresis after removal of the neutral and basic peptides on a column of 'Dowex 50'. The amino-acid composition of each of these, after total hydrolysis, was determined on paper and is presented in Table 2.

Table 2

| Peptide | Thr | Ser | Met $SO_3$ | Ala | Asp | Glu | Gly |
|---|---|---|---|---|---|---|---|
| 1 | − | × × × | × × | − | × × | *tr* | *tr* |
| 2 | × × × | × × × | − | − | *tr* | *tr* | *tr* |
| 3 | × × × | × × × | × × × | − | × | × | × |
| 5 | *tr* | × × × | × × | × × × | *tr* | *tr* | *tr* |
| 6 | × × × | × × × | × × × | × × × | *tr* | − | − |

Relative amounts indicated by ×'s and obtained by visual comparison of intensities. *tr* indicates small contamination.

Contamination by non-radioactive, acidic peptides was not great and so from Table 2 and the determined interrelationships of the peptides, represented in Fig. 2, these experiments indicated the sequence Thr.Ser.Met.Ala.

It is interesting that the sequence about the reactive serine in this enzyme is totally different from those determined for other di*iso*propylphosphoenzymes. They had in common an acidic amino-acid, the serine and a small neutral aliphatic residue. Comparing subtilisin with chymotrypsin, trypsin, elastase and thrombin, which are all endo-peptidases with different specificities, it would appear that the sequence immediately about the serine is not responsible for the unusual reactivity towards di*iso*propylphosphorofluoridate which results in the inhibition of the proteolytic activity. Some other grouping, possibly including histidine[14], which is spatially close due to folding of the chain, probably activates the serine.

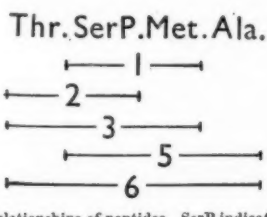


Fig. 2. Interrelationships of peptides. SerP indicates O-phosphoserine

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## PHYSIOLOGY

### Effect of Testicular Hyaluronidase on the Permeability of Human Arterial Tissue

The action of testicular hyaluronidase on acid mucopolysaccharides isolated from human aortic tissue was established in previous work from this laboratory[1]. The present investigation was undertaken with the purpose of studying the effect of testicular hyaluronidase on the permeability of arterial tissue membranes.

For determination of the tissue permeability, measurements were made of the diffusion coefficients of glucose for the membrane. The coefficient determinations were performed on three samples of the human aorta and three samples of the pulmonary artery, before and after the application of a solution of testicular hyaluronidase to the tissue, using the procedure of Johnson and Kirk[2]. After separation of the adventitia, intimamedia membrane samples of appropriate thickness were prepared. 50 ml. of a solution, consisting of 1 vol. 5 per cent glucose and 4 vol. Krebs's phosphate buffer, *p*H 7·1, were placed in the donor compartment of the diffusion apparatus, and 50 ml. of buffer solution in the recipient compartment. Two 1-hr. diffusion periods were first allowed to establish the permeability of the untreated membrane. Following this, the solutions were removed from the diffusion apparatus and the membrane and compartments rinsed with buffer solution. 5 ml. of a solution of testicular hyaluronidase (Alidase, Searle) in 0·05 *N* acetate buffer, *p*H 6·0 (30 viscosity units/ml.), were then introduced in both sides of the apparatus and were left in contact with the membrane for 2 hr. The membrane and the compartments were again rinsed with buffer solution, and glucose–buffer solution and buffer solution placed in the donor and recipient compartments. Diffusion coefficient measurements were then made in two 1-hr. periods. All experiments were carried out at 37° C. 30–45 min. were allowed to elapse

Table 1. Effect of Testicular Hyaluronidase on the Permeability of Human Arterial Tissue

| Sample | Thickness of membrane (mm.) | Diffusion coefficient of glucose | | | |
|---|---|---|---|---|---|
| | | Before hyaluronidase | | After hyaluronidase | |
| | | First period | Second period | First period | Second period |
| (1) Thoracic aorta | 0·63 | 0·000082 | 0·000084 | 0·000103 | 0·000134 |
| (2) Pulmonary artery | 1·15 | 0·000065 | 0·000070 | 0·000091 | 0·000089 |
| (3) Pulmonary artery | 0·96 | 0·000138 | 0·000111 | 0·000297 | 0·000330 |
| (4) Abdominal aorta | 1·33 | 0·000063 | 0·000050 | 0·000074 | 0·000134 |
| (5) Abdominal aorta | 0·92 | 0·000078 | 0·000086 | 0·000086 | 0·000079 |
| (6) Pulmonary artery | 0·89 | 0·000039 | 0·000033 | 0·000041 | 0·000044 |
| Mean | | 0·000078 | 0·000072 | 0·000115 | 0·000135 |

before each set of diffusion periods to permit penetration of glucose through the membrane.

The glucose analyses were performed in duplicate by the colorimetric method of Nelson[3], using the reagents described by Somogyi[4]. A Beckman *DU* spectrophotometer was employed for the colorimetric determinations.

The results of the experiments are presented in Table 1. It will be seen that a definite increase in the permeability of the arterial tissue to glucose was observed in four of the six experiments, whereas in two experiments no significant change was noted.

The diffusion coefficients observed for glucose for human arterial tissue in the present work before treatment with hyaluronidase are of the same order of magnitude as the values reported by Kirk and Laursen[5] for aortic tissue. The higher average values found in the second period following treatment with hyaluronidase may be due to a continued action of hyaluronidase in the tissue membrane.

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## Electro-shock Seizure Threshold of Metacorticoid Hypertensive Rats

It has been shown[1–5] that chronic administration of deoxycorticosterone acetate decreases brain excitability and potentiates anticonvulsant drugs, and that this effect is correlated with increased plasma and decreased brain intracellular sodium concentrations. In contrast, adrenal insufficiency produces the opposite effects[2]. Similarly, deoxycorticosterone acetate is known to be a relatively potent anæsthetic steroid[6].

Deoxycorticosterone acetate also produces, in the presence of dietary sodium, hypertensive cardiovascular disease and disturbances in mineral appetite. After the cessation of chronic administration of deoxycorticosterone acetate to rats, a metacorticoid state ensues in which these alterations persist[7,8]. It is felt that this hypertensive disease is mediated at least in part by increased arteriolar intracellular sodium[8,9]. It was of interest to determine whether the decreased brain excitability also persisted in metacorticoid rats.

Systolic blood pressures[10] and electro-shock seizure thresholds[11] were determined in 15 male Sprague-Dawley rats and in 30 similar rats that had previously received a subcutaneous implant of 20 mgm. deoxycorticosterone acetate and 1 per cent saline as drinking fluid for 3 months[8]. Both groups were being maintained on tap water, however, when blood pressure and electro-shock seizure thresholds were determined. The electro-shock seizure threshold refers to the convulsive threshold to a 60 counts per sec. current, delivered by corneal electrodes for 0·2 sec., that does not vary more than 1 m.amp. in 3 consecutive trials at least 48 hr. apart. The metacorticoid rats were found to have a mean electro-shock seizure threshold (35 m.amp.) that was not significantly different from that of the control rats (33 m.amp.), although their mean blood pressure (169 mm. mercury) was significantly elevated from control levels (129 mm.).

If the mechanism of electro-shock seizure threshold elevation by deoxycorticosterone acetate involves decreased brain intracellular sodium, and the mechanism of blood-pressure elevation by deoxycorticosterone acetate involve increased arteriolar intracellular sodium, then perhaps the former is reversible while the latter is not.

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## RADIOBIOLOGY

### Delayed 'Primary' Effects in *Chara vulgaris* L. subjected to X-Rays

'Primary' or 'non-localized' effects in the form of clumping of metaphase chromosomes or the sticking together of sister chromatids in cells that complete mitosis shortly after irradiation during the period when mitotic frequency is decreasing have already been described by numerous investigators.

Study of the restoration process in the freshwater alga *Chara vulgaris* L. ($n = 14$) on X-radiation has shown that the effects referred to as primary could still occur long after irradiation, although re-establishment of the normal structure had already been achieved.

Irradiation was performed with unfiltered X-rays delivered by a Machlett *A.E.G.* 50 beryllium-window X-ray tube operated at 40 kV. peak and 25 m.amp. The dose-rate at the target distance employed (12 cm.) was 14,000 r./min., measured in air. The

algae were irradiated under 5 mm. of tap water. The irradiation time ranged from 85 sec. (20,000 r.) to 28 min. (80,000 r.). After irradiation, the algae were put back in their normal culture conditions: filtered water from their place of origin, photo-period 16 hr., illumination 1,000 lux, temperature 20 ± 2° C.

In these conditions we observed for the most part that plants the telomes of which were treated with 20,000 r., 40,000 r. and 80,000 r., kept growing and formed whorls of phyloids having atypical morphology. Among these, however, a sudden restoration of the normal structure may occur after a series of 3–4 abnormal whorls. This process occurred about 5 weeks after irradiation. (A detailed study of the modalities of this process and survival and growth of irradiated algae will be published elsewhere.)

The mitosis of somatic cells in recovered whorls and of spermatogenous threads in antheridia borne by the former were investigated after fixing in modified Carnoy's fluid and staining with the Schiff reagent (Feulgen's method). This has shown a difference in the behaviour of nuclear divisions in these two cellular categories.

Whereas in the somatic cells the mitotic cycle is normal, without any appearance of chromosomic aberrations, on the contrary diverse mitotic disturbances were observed in the cells of the antheridial filaments. These differences are summarized in Table 1.

Table 1. Mitotic Aberration Frequencies in Spermatogenous Threads of *Chara*

| Mitotic aberration types per 100 cells | Dosage (kr.) | | | |
|---|---|---|---|---|
| | 0 | 20 | 40 | 80 |
| Clumping (metaphase) (Fig. 1) | 0 | 53·6 | 63·9 | 85·4 |
| Stickiness (anaphase) | 0 | 21·3 | 5·3 | 57·1 |
| Anaphasic bridges | 0 | 1·6 | 5·3 | 100 |
| Micronuclei | 0 | 5·8 | 0 | 4·8 |
| Pycnosis | 0 | 0 | 0 | 8·4 |

They are for the most part aberrations referred to as the usual 'primary', 'physiological' or 'non-localized' effects. The sister chromatid fusion results in bridge formation at anaphase.

The nuclei of the sperm mother cells resulting from these divisions also show different structural changes. With reference to Delay's work[1] on normal spermatogenesis in *Chara vulgaris*, the principal following abnormalities have occurred, especially in irradiated plants at 80,000 r.: (1) Central chromocentre ring, dumb-bell, filament shaped; (2) nuclear swelling or uneven contour of the nuclear membrane; (3) variation in nuclear volume; (4) nuclear fragmentation and pycnotic micronuclei.

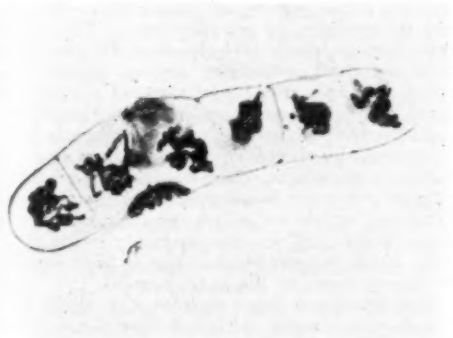

Fig. 1. Clumping in metaphase and stickiness in early anaphase. Spermatogenous thread of *Chara vulgaris* L. (× *c.* 1,500)

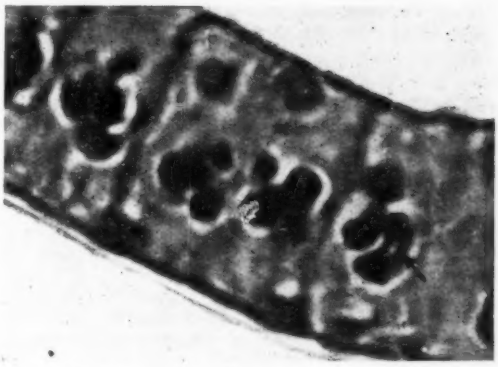

Fig. 2. Central vacuolization along the main axis (arrow) and degenerative pycnosis in the spermatozoids. Spermatogenous thread of *Chara vulgaris* L. (× 3,330)

Several degenerative processes occur in the spermatozoids: central vacuolization along the main axis and pycnosis (Fig. 2).

It is of interest to observe that aberrations referred to as primary effects can still appear at least 5 weeks following irradiation, after a minimum number of 12 mitoses between the irradiated apical cell and the antheridium initium, without the least mitotic damage being observed during the last nine divisions.

Thus it seems that these aberrations are bound with the metabolism of the nucleic acids in the course of spermatogenesis, whether this involves a depolymerization of deoxyribonucleic acid, as Darlington[2] and Taylor *et al.*[2] suggest, or partial dissociation of the nucleoproteins and damage to their organization pattern, as proposed by Kaufman[2].

These injuries due to X-rays are latent. The factor by means of which these injuries can be revealed is probably the very important heterochromatinization of the euchromocentric nuclei in the antheridial threads during spermiogenesis.

Moutschen and Dahmen[3] have stated that heterochromatin depolymerization and coalescence were emphasized by direct irradiation of the antheridia of *Chara vulgaris*. Moreover, some of the abnormal figures achieved by these authors immediately after direct irradiation are the same as those described here.

Effects referred to as primary are not limited to cells which complete mitosis immediately after irradiation; they can also occur in an organism long after X-ray treatment when the morphogenesis of the latter has again become normal. They can probably be transmitted by normal mitotic divisions and be revealed suddenly by a normal modification of nucleic acid metabolism in the nuclei heterochromatinization process during spermiogenesis in *Chara vulgaris*.

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## Fertility of Mice treated with Phosphorus-32

Since radioisotopes became available, many papers have been published concerning their clinical use as well as their potential harmful effects. One of these agents, phosphorus-32, is now occasionally being used in non-malignant conditions; consequently an effect which may be irrelevant in a cancer patient may become important in a young person who is likely to survive for some years; for example, the effect on the gonads. Previous knowledge on the subject is somewhat confusing[1–5], and no functional test has apparently been carried out so far.

The experiments reported here were carried out in *BALB* mice of both sexes, 1½–5 months old at the time of injection. Doses of phosphorus-32 ranging from 16 to 205 μc. were given intraperitoneally and the animals were mated with normal ones, previously checked for fertility, at periods of 1–8½ months after the administration of the agent. 3–12 months after treatment all the animals were killed and their ovaries and testes studied.

Tables 1 and 2 show the results obtained. 40 μc. seemed to be the threshold dose inducing sterility in all the females, since 6 of them so treated and mated with normal males revealed no pregnancy during 3–5 months of observation. With larger doses no pregnancies were encountered either, although the animals were kept under observation during periods up to 12 months. Males, however, were fertile even after receiving the largest dose administered, namely, 205 μc., which killed 5 out of 8 animals of this group. Since they were observed during periods ranging from 3 to 12 months, it seems safe to conclude that no dose short of the lethal one is capable of inducing sterility in males, whereas females become sterile with doses much below the lethal ones (approximately one-third *LD*50) and probably similar to those used in therapeutics.

Table 1. *BALB* Female Mice treated with Phosphorus-32

| Dose (μc.) | No. of females treated | No. of females pregnant |
|---|---|---|
| 16 | 2 | 2 |
| 28 | 8 | 3 |
| 34 | 5 | 4 |
| 40 | 6 | — |
| 60 | 2 | — |
| 90 | 6 | — |
| 120 | 8 | — |
| 200 | 3 | — |

Table 2. *BALB* Male Mice treated with Phosphorus-32

| Dose (μc.) | No. of males treated | No. of males fertile |
|---|---|---|
| 40·7 | 1 | 1 |
| 90 | 2 | 2 |
| 106 | 1 | 1 |
| 137 | 1 | 1 |
| 205 | 3 | 3 |

Ovaries and testes showed patterns generally in agreement with the observations of Bloom[1] and Odeblad[2]. However, no reappearance of the pearl formation in the ovaries, as described by Warren *et al.*[3], has been seen even 150 days after treatment. The results reported here seem to indicate that there is a real absence of oogenesis with doses of 40 μc. and not a decreased frequency as observed histologically by Warren *et al.* using much larger doses (250 and 2,000 μc.).

We are indebted to Fundaleu (Fundacion para combatir la leucemia), which partly supports the Seccion Leucemia Experimental, the Comision Nacional de Energia Atomica, for supplying us the radioactive phosphorus used, and E. R. Squibb and Sons, Argentina S.A., which partly supported this investigation.

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# ANATOMY

## Pattern of Hæmopoiesis in the Fœtal Liver

While the importance of the hæmopoietic role of the fœtal liver is universally recognized, remarkably little precise information is available about the changing cytology of this organ during the course of development. The recent interest in techniques for the transfusion of suspensions of human fœtal liver, as a source of hæmopoietic stem-cells, has, however, made it desirable to study more fully the processes of fœtal blood formation.

We are investigating the development of the blood and blood-forming tissues in the human embryo and fœtus, using quantitative methods wherever possible. In 35 fœtuses, obtained by hysterotomy between the second and seventh months of pregnancy, the livers have been examined both in sections and in smears.

The composition of the hæmopoietic cell population of the liver differs in a striking fashion from that of the bone-marrow (Fig. 1), and it would appear that the pattern of hæmopoiesis in the two situations is fundamentally different. Whereas the cytology of the bone-marrow suggests active erythropoiesis and granulopoiesis from the inception of the hæmopoietic process, that of the liver indicates an overwhelmingly erythropoietic pattern of hæmopoiesis and we can find no evidence of granulopoiesis. The occasional granulocytes which are observed in liver preparations are in all probability derived mainly from the blood. Bridges *et al.*[1] administered a suspension of fœtal liver to a patient suffering from pancytopenia, and afterwards observed a pronounced granulocytosis. It is possible, therefore, that the liver does in fact contain myeloblasts, which *in situ* fail to differentiate into granulocytes because of local metabolic conditions but which do so on reaching an appropriate environment. The liver certainly contains a few cells which we would confidently label myeloblasts if we saw them in the bone-marrow.

The liver and bone-marrow also differ in their lymphocyte content. Although no evidence of lymphocytopoiesis can be found in even the earliest bone-marrow, about one quarter of its nucleated cells are

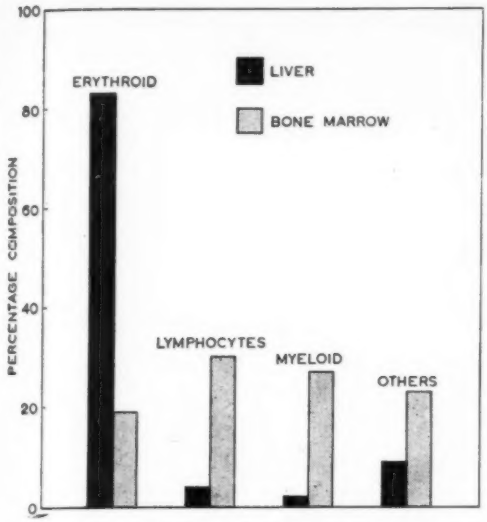


Fig. 1. Hæmopoietic cells of fœtal liver and bone marrow. Human fœtus, 202 mm. crown-rump length

lymphocytes; 15 per cent of these are transitional in appearance between typical small lymphocytes and hæmocytoblasts, resembling closely the cells previously described in the bone-marrow of the guinea pig by Yoffey[2]. In the liver, on the other hand, very few lymphocytes are seen and these, like the granulocytes in this situation, are probably derived from the blood.

The sparsity of lymphocytes in the fœtal liver, in which cell proliferation is extremely active, is difficult to reconcile with the view of Andreasen[3] and others, that lymphocytes are somehow mitotic adjuvants.

Furthermore, it seems unlikely that the lymphocytes of the bone marrow are concerned in antibody production, of which there is little evidence in early fœtal life. It would appear, therefore, that the lymphocyte population which is such a conspicuous feature of bone marrow—and presumably an indispensable cellular constituent from the earliest stages of development—must subserve a non-immunological function. The abundance of 'transitional' cells in fœtal marrow accords with the conclusion of Yoffey[4], that at least some of the small lymphocytes serve as hæmopoietic stem-cells in the marrow. Hæmopoiesis in the fœtal liver is quite unlike that in the bone marrow, for not only is it mainly erythropoietic, as has been noted already, but also the hæmopoietic stem-cell in this situation appears to be radically different from that in the marrow.

According to the widely accepted view of Maximow[5], it is represented by the undifferentiated mesenchymal cells which are trapped among the hepatic trabeculæ as they grow into the septum transversum. Our observations have failed to yield any evidence in support of this view. On the contrary, when mesenchyme occurs independently of hepatic trabeculæ, it contains very few differentiating hæmopoietic cells in comparison with the latter. Although occasional hæmocytoblasts and a variety of other immature hæmopoietic cells are seen intravascularly, in which situation they may undergo mitosis, the overwhelming majority of hæmocytoblasts and differentiating erythroid cells is extravascular, being found in the substance of the hepatic trabeculæ in intimate relationship with the liver cells. Here cells intermediate in appearance between hæmocytoblasts and early liver cells are observed in profusion and a complete morphological spectrum, linking the two, can be readily synthesized. We are, therefore, inclining more and more to the conclusion reached by Toldt and Zuckerkandl[6], that the hepatic hæmocytoblasts are derived not from the mesenchyme but from entoderm, namely, the as yet undifferentiated liver cells. In this connexion it is interesting to note that Gladstone and Hamilton[7] have ascribed an entodermal origin to the hæmocytoblasts of the human yolk-sac.

This work will be reported in detail elsewhere.

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## BIOLOGY

### Recapture in the River Tweed of a Sea-trout marked in Devonshire

During the winter of 1959–60 a number of sea-trout (*Salmo trutta* L.) kelts were tagged at the experimental fish trap installed by the Ministry of Agriculture, Fisheries and Food in the River Axe at Colyford, south Devon.

One of these fish, tagged on October 29, 1959, was recaptured on July 21 (266 days after liberation) in the estuary of the River Tweed, Northumberland, at the Yardford fishery situated about four miles from the mouth of the river.

The minimum distance travelled from the point of tagging to the point of recapture, via the Straits of Dover, is approximately 580 miles and via the Irish Sea is approximately 1,130 miles.

In addition to this recapture, a number of other sea-trout kelts similarly tagged at the trap last winter have been recaptured in the Rivers Otter (1), Exe (1), Teign (4), Erme (1) and Taw (1). In the last case, the minimum distance travelled was 244 miles in 174 days. Two of the fish caught in the Teign were taken in fresh water several miles above the tideway but the others were taken in the estuaries of the various rivers. The extent of the migrations of sea-trout in the sea are almost entirely unknown and these observations suggest that they are more extensive than has hitherto been supposed.

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## Interspecific Hybrids of *Tilapia*: *T. nigra* × *T. zillii*

The increasing recognition of fish (and in the tropics of *Tilapia* in particular) as farm animals has stimulated interest in the breeding of new and useful strains. In Malacca, Hickling[1] hybridized two geographical stocks of *Tilapia mossambica* Peters to produce both a faster growing strain as well as a skewed sex ratio in favour of males, the latter greatly simplifying the monosex culture technique of Brown and van Someren[2]. Hybrids have now been reported between *T. nilotica* (Linné) and *T. galilaea* (Artédi)[3], but their value for fish culture has not yet been assessed. Field observations led Lowe to suspect hybridization of the former with *T. nigra* (Günther) and *T. esculenta* Graham in Uganda[4].

The species involved in these crosses are female mouth-brooders. Although all show a basic similarity in breeding pattern, quite distinct from that of male mouth-brooders or substratum-spawners (as defined by Lowe[5]), interspecific differences, especially in courtship and male breeding coloration, have been considered important barriers to natural hybridization. It is therefore of great interest to record hybrids between the mouth-brooder *T. nigra* and the substratum-spawner *T. zillii* Gervais. It is difficult to imagine two more dissimilar species of *Tilapia*. They show striking differences, not only in breeding patterns but also in anatomy, behaviour and feeding habits.

Hybrids were found in a flooded rice paddy on the Tebere rice irrigation scheme in Kenya which had been stocked with *T. nigra*, but into which two male *T. zillii* had gained entry. Similar hybrids were also found in Lake Naivasha, Kenya, which had been stocked with both species. The hybrids were recognized in the field principally by coloration: dark body-shape the hybrids conformed to *T. nigra*; and the iridescent blue sheen of *T. zillii*; light, pearly green spots on the body and on dorsal, anal and caudal fins; no trace of the crimson flush on the chest found in breeding *T. zillii*, and no dorsal '*Tilapia*-mark'; and six or seven dark vertical bars on the body (absent in large *T. nigra*). In general body-shape the hybrids conformed to *T. nigra*; however, in all but one case the mouths were noticeably smaller. The Tebere hybrids also exhibited a 'gasping' behaviour (protrusion of the mouth) and tended to erect dorsal and anal fins when handled, a behaviour found in *T. zillii* but rare in *T. nigra*.

In most anatomical characters the hybrids resembled *T. nigra*, but (except in one case) larger specimens lacked the enlarged snout (elongation of the horizontal ramus of the premaxilla) associated with that species. Premaxilla, maxilla, dentary and articular were slightly shorter than in *T. nigra*, but less robust than those of *T. zillii*. Otherwise neurocranial, branchiocranial and pectoral elements, very different in the two species, were in the hybrids within the range of proportions found in *T. nigra*. Jaw and pharyngeal dentition resembled that of *T. nigra*, although simplification of the outer jaw teeth appeared to have been retarded slightly. Some hybrids had the three anal spines of *T. zillii*, while others had four anal spines (found in 10–20 per cent of natural populations of *T. nigra*). Five anal spines, the normal in *T. nigra*, occurred in 11 per cent of the Tebere hybrids.

Since female hybrids were not recognized in the field, but afterwards when post-mortem colour changes had eradicated the hybrid coloration, and since the few females found had either four or five anal spines, it is possible that female *T. nigra* were included in the samples. In most cases testes were well developed, and breeding occurred in ponds stocked with three- and four-spined males and five-spined females. No three-spined progeny were produced and the fry resembled *T. nigra* in all respects, including coloration. The cross male *T. zillii* × female *T. nigra* has been repeated at the Inland Fishery Research Station at Sagana in Kenya, and a brooding female was found after six weeks. The results of the reverse cross are not known.

Although the hybrids appear to be fertile, a skewed sex ratio may occur. Alternatively, spine-counts may facilitate the determination of the sex of small fishes. The production of a sterile or predominantly male weed-eating hybrid seems at present unlikely, only four hybrids having apparently fed on higher plants as does *T. zillii*.

These results will be reported more fully elsewhere.

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## Occurrence of *Pyrosoma* on the Continental Slope

Hurley and McKnight[1] have reported that the pelagic tunicate *Pyrosoma atlanticum atlanticum* rests on or swims just above the sea-floor at a depth of 160–170 metres. Indirect observations made on this species in the course of a line-fishing survey of the fishes of the south-eastern Australian continental slope[2] corroborate the concentration of this species near the sea-floor and extend the habitat to the floor of the continental slope.

While fishing off the east coast of Tasmania during June 1954–July 1955, 1,141 specimens of *Hyperoglyphe porosa* (Richardson) (deep-sea trevally)—previously considered to be quite rare—were taken by dropline in depths ranging from 330 to 640 m. These fish were found to feed almost exclusively upon *Pyrosoma*, their stomachs often being crammed full with the tests of this organism. Of 363 stomachs containing food 86 per cent contained the tests of large colonies of *Pyrosoma*. Fish having *Pyrosoma* in their stomachs were taken on hooks set 2–48 m. from the floor of the continental slope. Since fish were never taken until the fishing gear was touching bottom it is assumed that *Pyrosoma* were available at these depths. This would seem to be confirmed by the observations of Hurley and McKnight[1]. With one exception, all fishing operations were carried out during the hours of daylight, the incidence of *Pyrosoma* in the stomachs showing no significant variation throughout the day. Only 5 fish were taken at night and these had empty stomachs.

Thompson[3] recorded occurrences of *Pyrosoma* from Tasmanian waters at all seasons of the year and at all depths examined (0–500 m.) and was unable to discern any particular season of maximum occurrence.

From an examination of the stomach contents of *Hyperoglyphe* off the east coast of Tasmania in June, July, September and October 1954, and in January, March, May and July 1955, it was apparent that the incidence of *Pyrosoma* in the stomachs was at its maximum during the months of January and March. No other food organism became dominant at any time, so the incidence of *Pyrosoma* in the stomachs may reflect the seasonal abundance of the tunicate, though it could possibly reflect seasonal variation in the feeding intensity of the fish.

The specimens of *Pyrosoma* were identified by Mrs. M. Mather of the Zoology Department, University of Queensland.

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Research Organization,
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Cronulla, Sydney.

[1] Hurley, D. E., and McKnight, D. G., *Nature*, **183**, 4660 (1959).
[2] Cowper, T. R., and Downie, R. J., C.S.I.R.O., Aust. Div. Fish. Oceanogr. Rep. No. 6 (1957).
[3] Thompson, Harold, "Pelagic Tunicates of Australia" (Commonwealth Council for Scientific and Industrial Research, Australia, Melbourne, 1948).

## MISCELLANY

### 'Dex' or 'Order of Magnitude' ?

The phrase 'order of magnitude' is in constant use. It has at least two different meanings. In astronomy the magnitude of star $A$ exceeds that of star $B$ by unity if the amount of radiation (measured visually, photographically or bolometrically) reaching an observer or instrument on the Earth in a given time from $A$ is $10^{-0.4}$ or 0·3981 times that from $B$. In other sciences $A$ is said to exceed $B$ by an order of magnitude if it is ten times as large. To take an example, Lowy[1] wrote, "Thus, in the tonic anterior byssus retractor of *Mytilus*, the decay of tension can be two orders of magnitude slower than that of the active state". I take it that this means that the time needed for the tension to fall to a given fraction of its initial value after tonic contraction can be 100 times greater than the corresponding time after active contraction.

There is a shorter and more precise word to express such a comparison. This is the word 'dex', for 'decimal exponent', due to Allen[2,3]. He defines it as follows. "Dex converts the number before it into its 10-based antilogarithm. The term can be used for a typographically convenient method of expressing large numbers, as in the example $10^{39}$ = 39 dex. It can also be used to introduce verbal simplicity into statements on probable errors, ranges, and variations." He gives, among others, the example "The frequency range of useful radio-astronomy observations is 3·2 dex".

I suggest that outside astronomy 'dex' can always be substituted for 'order of magnitude' with advantage. I give a few examples from biology. "The range of weights of vertebrates is 10 dex, that of weights of birds only 4 dex." "A man consists of about 14 dex of cells." "The ratio of length to breadth in a nerve fibre can exceed 6 dex." "There are about 11 dex of birds." "The coefficient of variation of linear dimensions of unworn mammalian teeth rarely exceeds 0·05 dex." "The human ear has a frequency range of about 3·5 dex (1 octave = 0·301 dex) but the range of tones used in music is only 2·1 dex."

It can also be used with advantage in the social sciences, for example, "There are 8·6 dex of human beings in India, and about 8 dex of adult males. The range of incomes certainly exceeds 3 dex and may exceed 4".

Biologists will have to learn to think rapidly in terms of large numbers, as physicists, chemists, astronomers, and geologists do already; and even in the case of small numbers, the use of the word 'dex' may be an aid to precision of thought. I venture to hope that it may also be taken over from the terminology of astrophysics into other non-biological sciences. I am trying to use it systematically in lectures in this Institute.

J. B. S. Haldane

Indian Statistical Institute,
Calcutta, 35.

[1] Lowy, J., *Nature*, **184**, 1445 (1959).
[2] Allen, C. W., *Observatory*, **71**, 157 (1951).
[3] Allen, C. W., "Astrophysical Quantities" (London, 1955).

## PSYCHOLOGY

### Effects of Medial Temporal Lesions on Taste Preference in the Monkey

Monkeys with lesions in the medial portions of the anterior temporal lobes (the amygdala and pyriform cortex) tend to show marked changes in their responses to events that, pre-operatively, served as rewards or punishments. For example, it has been claimed that animals tend to be unafraid of snakes and strange people, to mount inanimate objects, to ingest a host of objects that were unacceptable pre-operatively. According to one descriptive generalization[1] monkeys are still motivated by reward and punishment, but the classes of events that are rewarding or punishing alter. In order to examine this view more specifically and also to rule out the possibility that the changes in reward–punishment classification occur simply because of changes in sensory capacity, the following experiments were undertaken.

Prior to operation saccharine preference curves for ten monkeys were determined. Each animal was given daily tests with one drinking dish containing distilled water and the other one containing saccharine sodium in one of four concentrations (1·0, 0·25, 0·05, 0·017 per cent). The actual concentration given on any day and the positions of the two dishes were randomized. Once a week both dishes contained distilled water.

This procedure lasted five weeks, so that a reasonably stable preference curve for each animal could be determined. Typically monkeys showed an aversion for the 1 per cent concentration and a moderate preference for the 0·017 per cent concentration, with a clear and strong preference for the middle two concentrations. Throughout the entire experiment, monkeys were provided with unlimited quantities of their standard diet of diet 41 lab chow, with vitamin C added.

In addition, with six of the monkeys, absolute thresholds for saccharine were determined using a method that does not depend upon the animal's preference for saccharine. The animal was trained to lick up 5 drops of a solution placed upon a piece of aluminium foil clamped to the top of a small iron

cylinder. Until the animal made the licking response, the cylinder was held firmly in place by means of an activated electromagnet placed directly beneath it. If the solution was distilled water, the animal could then lift the cylinder within 10 sec. following the licking response and obtain a small piece of apple placed within it. If the solution was a saccharine solution, the animal was rewarded directly by the experimenter (who was situated behind a one-way vision screen) if he did not lift the cup for at least 10 sec. following the licking response. By systematically varying the concentration of saccharine, the point at which a weak concentration could no longer be discriminated from water was determined. The aluminium foil was renewed on each trial and an interval of 1 min. was inserted between all trials to allow for adaptation. An opaque screen was lowered between trials so that the animal could not see the solution being placed on the foil. The fact that thresholds were obtained indicates that the animals were not using extraneous cues in making their responses.

After these tests had been carried out, six of the monkeys were given bilateral medial temporal lesions, three were given partial striate cortex lesions, and one was given an anterior frontal lesion. All threshold and preference tests were then repeated, beginning one week post-operatively.

The results indicated that the absolute threshold for saccharine was not detectably altered in the six medial temporal monkeys. The average threshold was of the order of 0·008 per cent pre-operatively and post-operatively. Preference for saccharine, however, underwent a clear change in the medial temporal group as indicated in Figs. 1 and 2. The stronger concentrations became much more preferred than they had been pre-operatively. The weak concentrations

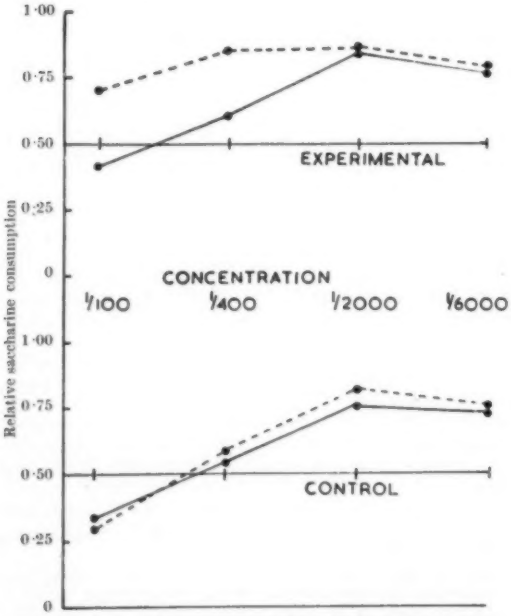


Fig. 1. Mean preference curves. The ordinate represents consumption of saccharine divided by saccharine plus distilled water. Each point is the average of all animals in each group, at least six determinations per animal with each concentration. ——, pre-operative; – – –, post-operative

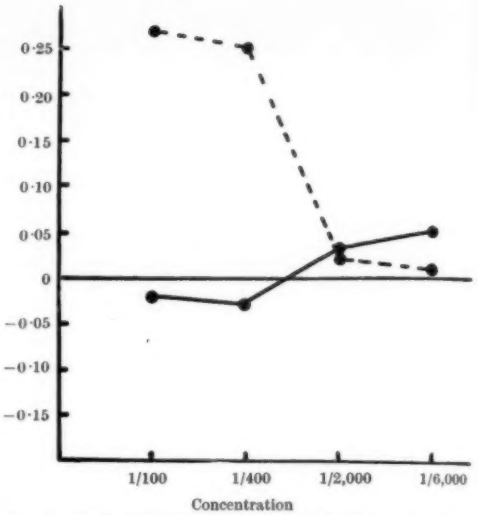


Fig. 2. Mean preference change. The ordinate represents the difference between post-operative and pre-operative preferences with each concentration, determined for each animal and then averaged. ——, Controls; – – –, experimentals

did not change. In the striate control group, if there was any trend, it was in the opposite direction. (The data for frontal monkeys are not included in these graphs. As has been found in earlier studies, for example, ref. 2, they fell between the medial temporal and control group results.) Of the six medial temporal animals, all showed an increase in preference for the strongest solution; all three striate monkeys showed a slight decrease. Associated with the increase in preference for strong saccharine was, in some cases, a large increase in fluid intake for those solutions. One monkey, for example, consumed an average of 3,550 c.c. a day of the 0·25 per cent solution, which was almost equal to his own body-weight. On the weak concentrations, however, and on water versus water, there was no change in the total fluid intake, indicating that a simple diabetes insipidus will not account for the results.

The results confirm, threfore, the view that medial temporal lesions change preferences—and thereby the relative strength of rewards—without changing the sensory capacity to discriminate the rewards. The experiments also incidentally point out the inadequacy of measuring changes in taste threshold in animals by means of preference, as is frequently done.

The preference results are unexpected in their direction. It was predicted, from gross observations, that the monkeys would become more indiscriminate, that is, tend to show no clear preference between saccharine and water. Instead, they became virtually saccharine 'addicts', especially for strong concentrations. Further work is therefore necessary to determine whether medial temporal monkeys prefer any strong testing substance or whether the change is specific to the dimension of sweetness. There is some evidence that the former alternative is likely.

L. Weiskrantz

Psychological Laboratory,
University of Cambridge.

[1] Weiskrantz, L., *J. Comp. Physiol. Psychol.*, **49**, 381 (1956).
[2] Weiskrantz, L., and Wilson, jun., Wm. A., *J. Comp. Physiol. Psychol.*, **51**, 167 (1958).

# FORTHCOMING EVENTS

## Sunday, September 4—Wednesday, September 7

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE (at Cardiff)—Continuation of 122nd Annual Meeting.

**Sunday, September 4**

At 11 a.m.—Service at Llandaff Cathedral. Preacher: The Bishop of Llandaff.

**Monday, September 5**

At 10 a.m.—Symposium on "World Food and Population". Chairmen: Sir George Thomson, F.R.S., and Sir James Gray, F.R.S. Principal Speakers: Dr. N. C. Wright, Prof. D. V. Glass, Prof. W. A. Lewis, Dr. L. Dudley Stamp, Sir Alexander Fleck, F.R.S., Dr. H. D. Kay, F.R.S., Prof. P. M. S. Blackett, F.R.S.

At 8 p.m.—Dr. E. B. Chain, F.R.S.: "Microbiological Methods in the Development of Drugs" (Evening Discourse).

**Tuesday, September 6**

At 10 a.m.—Mr. G. F. Mitchell: "Pleistocene History of the Irish Sea" (Presidential Address, Section C).

At 10 a.m.—Prof. D. V. Glass: "Population Growth, Fertility and Problems of Policy" (Presidential Address, Section N).

**Wednesday, September 7**

At 10 a.m.—Mr. Martin J. Wells: "What the Octopus Makes of it: Our World from Another Point of View" (Darwin Lecture).

## Wednesday, September 7

INSTITUTE OF PETROLEUM (at 61 New Cavendish Street, London, W.1), at 5.30 p.m.—Mr. D. Downs, Mr. S. T. Griffiths and Mr. R. W. Wheeler: "The Part Played by the Preparational Stage in Determining Lead Anti-Knock Effectiveness".

POLAROGRAPHIC SOCIETY (at "The Feathers", Tudor Street, London, E.C.4), at 7 p.m.—Informal Discussion Meeting on "The Use of Ion Exchange Water in Polarography".

## Thursday, September 8

PHYSICAL SOCIETY, ACOUSTICS GROUP (in the new Physics Building Imperial College, South Kensington, London, S.W.7), at 9.30 a.m.—Symposium on "Sound Propagation in the Atmosphere".

# APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT IN VETERINARY PHARMACOLOGY in the University of Glasgow Veterinary Hospital—The Secretary of University Court, The University, Glasgow (September 9).

ASSISTANT INSPECTORS OF FISHERIES (2) (male, not over 40, with a degree, or equivalent in zoology, plus adequate knowledge of botany) IN THE DEPARTMENT OF LANDS, Dublin—The Secretary, Civil Service Commission, 45 Upper O'Connell Street, Dublin (September 9).

ASSISTANT EXPERIMENTAL OFFICER (with a degree in science or horticulture) IN THE ENTOMOLOGY SECTION—The Secretary, National Vegetable Research Station, Wellesbourne, Warwick (September 10).

BIOCHEMIST (Top grade) (well qualified chemist, preferably with a medical qualification) TO BE HEAD OF THE DEPARTMENT OF BIOCHEMISTRY—The Secretary, United Birmingham Hospitals, Queen Elizabeth Hospital, Birmingham 15 (September 10).

SENIOR LECTURERS (2) (preferably with a good honours degree and teaching or other suitable experience), one to teach electrical engineering and the other to teach electronics to equivalent degree level for Sandwich Diploma Courses—The Principal, Royal Radar Establishment College of Aeronautics, Malvern (September 10).

TECHNICIAN (preferably with experience in photography) IN THE DEPARTMENT OF ZOOLOGY—The Registrar, University College of Wales, Aberystwyth (September 10).

TUTORIAL STUDENT (graduate, or about to graduate) IN THE DEPARTMENT OF GEOGRAPHY—The Registrar, King's College (University of London), Strand, London, W.C.2 (September 10).

SENIOR LECTURER (with qualifications in either pure or applied mathematics) IN MATHEMATICS at the University of Canterbury, Christchurch, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, September 16).

LECTURER (graduate with experience in the dairy industry or of dairy teaching) IN DAIRYING—The Registrar (Room 22, O.R.B.), The University, Reading (September 17).

RESEARCH FELLOWS (2) (preferably with a Ph.D. degree in engineering or physics, or equivalent research experience) IN THE DEPARTMENT OF ELECTRICAL ENGINEERING (under Prof. A. L. Cullen), for work in the field of millimetre waves techniques—The Registrar, The University, Sheffield (September 17).

BRITISH OIL AND CAKE MILLS RESEARCH FELLOW (graduate, preferably with honours, in agriculture, economics or pure science) IN THE DEPARTMENT OF AGRICULTURE—The Professor of Agriculture, The University, Leeds 2 (September 21).

LECTURER/ASSISTANT LECTURER (with a good honours degree with suitable research and teaching experience, together with a good knowledge of both plant and animal biochemistry) TO TEACH AGRICULTURAL BIOCHEMISTRY at the University of Malaya, Kuala Lumpur—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Kuala Lumpur and London, September 30).

LECTURER IN CHEMICAL ENGINEERING at the University of Canterbury, Christchurch, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, September 30).

PHYSICIST or SOIL PHYSICIST (Ref. SD.1) (with a first- or second-class honours degree in physics with at least two years postgraduate experience in research or in natural science with at least two years experience or training in soil science), for research on the mechanical and physical properties of agricultural soils and their relationship to the performance of tillage implements; and an ENGINEER (Ref. SD.2) (with a first- or second-class honours degree in mechanical or agricultural engineering or equivalent and with postgraduate experience in agriculture), for research on the design and performance of ploughs and cultivation machinery and on improved methods of cultivation—The Secretary, National Institute of Agricultural Engineering, Wrest Park, Silsoe, Bedfordshire, quoting appropriate Ref. No. (September 30).

SENIOR LECTURER IN FARM MANAGEMENT in the INSTITUTE OF AGRICULTURE, the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, September 30).

SENIOR LECTURER IN PREHISTORY IN THE DEPARTMENT OF ANTHROPOLOGY, University of Auckland, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, September 30).

SENIOR LECTURER and a LECTURER (with a degree in science or in agriculture, followed by postgraduate training in biochemistry, and previous experience in teaching or research) IN BIOCHEMISTRY at Canterbury Agricultural College, University of New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, October 15).

SENIOR LECTURER IN CYTOLOGY AND GENETICS at the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, October 15).

SENIOR LECTURER or LECTURER IN PHYSICS at the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, October 31).

UNIVERSITY LECTURER (with at least an honours degree in psychology and some knowledge of statistical methods) IN PSYCHOLOGY—The Secretary, Cambridge University Department of Education, 17 Brookside, Cambridge (November 3).

ASSISTANT PROFESSOR (Ph.D. or M.B.) IN PHARMACOLOGY—Prof. M. F. Murnaghan, University of Ottawa, Ottawa, Ontario, Canada.

ASSISTANT PROFESSOR OF PHARMACOLOGY—Prof. J. G. Aldous, Department of Pharmacology, Dalhousie University, Halifax, N.S., Canada.

ASSOCIATE PROFESSOR (preferably Ph.D.) OF HORTICULTURE at the University of Saskatchewan, Saskatoon, Saskatchewan, Canada—The Agent-General for Saskatchewan, 19 Chester Mews, London, S.W.1.

COMPUTER (preferably woman graduate) for the MATHEMATICS DEPARTMENT—The Assistant Secretary, University College, Gower Street, London, W.C.1.

COUNTY LABORATORY RESEARCH FELLOW, to work in the field of hair growth in collaboration with Dr. F. J. Ebling—Dr. F. J. Ebling, Department of Zoology, The University, Sheffield.

GEOLOGIST (man or woman, aged 23–45, with a degree in geology, general experience in geology and geophysics, and a knowledge of the occurrence of ground water) with the Government of Kenya, for the location of sites for water boring, geological mapping with special reference to the occurrence of ground water and general investigations connected with engineering problems—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.112/7/044/T.

HEAD (well qualified chemical engineer with responsible industrial experience, including that of original design, and preferably previou experience and/or research experience relevant to the developmen of undergraduate and postgraduate work in collaboration with industry t OF THE DEPARTMENT OF CHEMICAL ENGINEERING—The Registrar, Bradford Institute of Technology, Bradford 7.

LECTURER (with a good honours degree and teaching experience) IN THE SCIENCE DEPARTMENT, to teach pure and applied mathematics and statistics to G.C.E. Advanced Level and B.Sc. General degree students—The Clerk to the Governors, South-West Essex Technical College and School of Art, Forest Road, Walthamstow, London, E.17.

LECTURER or SENIOR LECTURER (with a university degree in medicine and preferably with interest in applied pharmacology and therapeutics) IN PHARMACOLOGY—The Secretary, Charing Cross Hospital Medical School, 62–65 Chandos Place, London, W.C.2.

PHYSIOLOGIST, Assistant Professor or Associate Professor (with an M.D. or a Ph.D. degree and capable of independent research)—Prof. M. Beznak, Department of Physiology, University of Ottawa, Ottawa, Canada.

POSTDOCTORAL FELLOWS IN THE DEPARTMENT OF CHEMISTRY, for research work in the fields of electron spin resonance spectroscopy of free radicals at liquid helium temperature, and mass spectrometry, including photo-ionization studies—Prof. C. A. McDowell, Department of Chemistry, University of British Columbia, Vancouver 8, B.C., Canada.

RESEARCH ASSISTANT for wind tunnel investigation in the field of industrial aerodynamics—Head of the Aeronautics Department, Imperial College of Science and Technology, South Kensington, London, S.W.7.

RESEARCH ASSISTANT (PHYSICIST) (preferably with a knowledge of electronics and a degree in physics), for work with the X-ray scanning microanalyser (electron probe) in the field of ore microscopy—Dr. A. P. Millman, Mining Geology Department, Royal School of Mines, Prince Consort Road, London, S.W.7.

RESEARCH ASSOCIATE IN CHEMISTRY, to work on the physical chemical properties and synthesis of heteropoly compounds—Prof. Egon Matijevic, Department of Chemistry, Clarkson College of Technology, Potsdam, New York, U.S.A.

TECHNICAL OFFICER (aged 22–25, with a degree in mathematics or an honours degree in geography with a mathematical background) IN THE SURVEY DEPARTMENT, Government of Kenya, for survey computations and checking of survey plans—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.103/7/09/Cl.

# REPORTS and other PUBLICATIONS

*(not included in the monthly Books Supplement)*

## Great Britain and Ireland

Ministry of Agriculture, Fisheries and Food. Bulletin No. 34 : Mushroom Growing. Seventh edition. Pp. v+66+16 plates. (London : H.M. Stationery Office, 1960.) 6*s*. net. [226

Department of Scientific and Industrial Research. Torry Research 1959 on the Handling and Preservation of Fish and Fish Products : Report of the Torry Research Station Steering Committee, and Report of the Director of the Torry Research Station. Pp. iv+31. (London : H.M. Stationery Office, 1960.) 2*s*. 6*d*. net. [226

British Empire Cancer Campaign. Thirty-seventh Annual Report covering the year 1959. Part 1 : The Chairman's Statement and the Accounts. Part 2 : The Scientific Report of the Researches undertaken by the Central Organisation and Its Autonomous Councils in the United Kingdom, and by some of Its Affiliated Organisations Overseas. Pp. liv+666. (London : British Empire Cancer Campaign, 1960.) [226

Association of British Manufacturers of Agricultural Chemicals. Pharmacy and Poisons Act 1933 and Poisons Rules 1960 relating to the sales of Insecticides, Fungicides, Weedkillers, Rodenticides. Pp. 15. (London : Association of British Manufacturers of Agricultural Chemicals, 1960.) 3*s*. [226

An Outline of Luvale Social and Political Organization. By C. M. N. White. (The Rhodes-Livingstone Papers, No. 30.) Pp. xiii+52. (Manchester : The University Press, 1960. Published on behalf of the Rhodes-Livingstone Institute.) 8*s*. 6*d*. net. [226

Philosophical Transactions of the Royal Society of London. Series *B* : Biological Sciences. No. 699, Vol. 243 (16 June 1960) : The Structure and Function of the Respiratory Horns of the Eggs of some Flies. By H. E. Hinton. Pp. 45–73. (London : Royal Society, 1960.) 11*s*. [226

Institution of Gas Engineers. Publication No. 565 : 97th Annual Report and Accounts of the Council of the Institution of Gas Engineers. Pp. 46. Publication No. 566 : Presidential Address given at the 97th Annual General Meeting, Edinburgh, 31st May to 3rd June, 1960. By Duncan D. Melvin. Pp. 16. Publication No. 567 : The Westfield High-Pressure Coal-Gasification Plant. By T. S. Ricketts. Pp. 66. Publication No. 568 : Gasification at the Isle of Grain. By C. Stott. Pp. 55. Publication No. 569 : The Architect and the Gas Engineer : Their Purpose, Responsibilities and Inter-Relationship. By R. Baden Hellard. Pp. 36. Publication No. 570 : The Development of the Industrial Gas Load in Scotland. By A. Higgs and R.W. Deans. Pp. 53. Publication No. 571 : Coke in a Changing Market. By Dr. F. A. Burden and D. G. Rose. Pp. 31. Publication No. 572 : White Lund—Some Aspects of a New Works. By F. C. Buckley. Pp. 40 (7 plates). Publication No. 573 : Live Gas. By Stirling Everard. Pp. 21. Publication No. 574 : Official Programme, 97th Annual General Meeting, Edinburgh, 31st May to 3rd June, 1960. Pp. 12. (London : Institution of Gas Engineers, 1960.) [226

Royal Physical Society of Edinburgh. Proceedings of Meetings devoted mainly to Experimental Biology and Natural History. Vol. 28, Parts 1 and 2 : The Cell Surface. (Second Symposium of the Society held in Edinburgh on 22nd and 23rd May, 1959.) Pp. viii+1–122 +plates 1–3. Price of *Proceedings* per volume (three parts) to Non-Fellows—25*s*. (Edinburgh : Oliver and Boyd, Ltd. Obtainable from the Secretary and Executive Editor, Dr. H. Kacser, Department of Animal Genetics, University of Edinburgh, King's Bldgs., Edinburgh, 9.) [226

De Havilland Propellers Limited. The De Havilland Anatrol Low Cost On-line Computor : Analogue Computer for the Process Industries. Pp. 6. (Hatfield : De Havilland Propellers, Ltd., 1960.) [226

Scottish Society for Research in Plant Breeding. Report of the Scottish Plant Breeding Station, 1960. Pp. 105. (Pentlandfield, Roslin : Scottish Plant Breeding Station, 1960.) [226

Department of Scientific and Industrial Research : Road Research Laboratory. Road Research Technical Paper No. 49 : Road Accidents —Christmas 1959 : an Investigation of the Fatal Road Accidents in England and Wales, December 24th–27th, 1959. Pp. iv+20. (London : H.M. Stationery Office, 1960.) 1*s*. 9*d*. net. [226

Ministry of Education : Scottish Education Department. Grants to Students : Report of the Committee appointed by the Minister of Education and the Secretary of State for Scotland in June, 1958. Pp. xii+135. (Cmnd. 1051). (London : H.M. Stationery Office, 1960.) 6*s*. 6*d*. net. [226

Commonwealth Relations Office—Colonial Office. Commonwealth Educational Co-operation. Pp. 7. (Cmnd. 1032). (London : H.M. Stationery Office, 1960.) 6*d*. net. [226

Universities Council for Adult Education. Report on the year 1958–1959. Pp. 34. (Bristol : W. E. Salt, Hon. Secretary and Treasurer, The University, 1960.) [226

Air Ministry : Meteorological Office. Scientific Paper No. 1 : Airborne Measurements of the Latitudinal Variation of Frost-Point, Temperature and Wind. By N. C. Helliwell. Pp. ii+30. (M.O. 664). (London : H.M. Stationery Office, 1960.) 3*s*. 6*d*. net. [226

Regent Advertising Club. If You Want to get into Advertising here's how you can help Yourself. Pp. 14. (London : Regent Advertising Club, 1960.) [226

Research Defence Society. Conquest Pamphlet No. 11 : Vaccination Against Whooping-Cough, Diphtheria and Tetanus : Outstanding questions posed and answered by the Research Defence Society. Pp. 16. (London : Research Defence Society, 1960.) 6*d*. [226

*Bulletins of Marine Ecology* (formerly *Hull Bulletins of Marine Ecology*). No. 41, Vol. V (May 1960) : Continuous Plankton Records : Methods of Analysis, 1950–1959. By J. M. Colebrook. Pp. 51–64. (Edinburgh : Scottish Marine Biological Association, 1960.) 6*s*. 6*d*. [226

Tobacco Manufacturers' Standing Committee. Research Papers, No. 3 : The Constituents of Tobacco Smoke—First Supplement. Edited by H. R. Bentley and E. G. N. Berry. Pp. i+25. (London : Tobacco Manufacturers' Standing Committee, 1960.) [226

Empire Cotton Growing Corporation. Annual Report for the year ending 31st March 1960. Pp. ii+21. (London : Empire Cotton Growing Corporation, 1960.) [236

Department of Scientific and Industrial Research. Water Pollution Research 1959 : The Report of the Water Pollution Research Board with the Report of the Director of the Water Pollution Research Laboratory. Pp. vi+115+4 plates. (London : H.M. Stationery Office, 1960.) 7*s*. net. [236

## Other Countries

Annals of the New York Academy of Sciences. Vol. 79, Article 10 : Biology of the Pleuropneumonia-like Organisms. By D. G. ff. Edward and 79 other authors. Pp. 305–758. 5 dollars. Vol. 86, Article 2 : Modern Concepts of Thyroid Physiology. By Rulton W. Rawson and 49 other authors. Pp. 311–676. 3.50 dollars. (New York : New York Academy of Sciences, 1960.) [36

University of California Publications in Geological Sciences. Vol. 34, No. 5 : Origin of Rock Creek and Owens River Gorges, Mono County, California. By William C. Putnam. Pp. 221–280+plates 31–40. (Berkeley and Los Angeles : University of California Press ; London : Cambridge University Press, 1960.) 2 dollars. [36

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